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NEWTON'S PHILOSOPHY OF NATURE[1]

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IT would seem to be a waste of time to discuss Newton's philosophy of nature, if the judgment of Professor Burtt is correct:[2] "In scientific discovery and formulation Newton was a marvelous genius; as a philosopher, he was uncritical, sketchy, inconsistent, even second-rate."

The opinion of Professor Burtt should rather read: Newton was of purpose not a philosopher, if philosophy be limited to a study of ultimate reality and the most general causes of things, as many modern metaphysicians wish to define it. The criticism has also its humorous side; since the author then proceeds to show that the ideas of Newton, *malgré lui*, are metaphysical. However, the reform of science instituted by Bacon, and completed by the genius of the seventeenth century, was founded on the thesis that science should not be concerned with ultimate reality and causes; since then, science has been more and more restricted to the enquiry of *how* things occur, and not of *why*. In other words, if there is a natural philosophy, it must be defined in its original and widest sense, as a love or pursuit of the knowledge of things, whether theoretical or practical.

It would even seem, according to a metaphysician, Newton was not a philosopher because of his "marvelous genius"; yet, to his contemporaries he was the "incomparable," because of his insistence that hypothesis should be no part of natural philosophy. My essay, to avoid even the semblance of erudition, will be concerned with what he contributed towards the downfall of the scholastic system, and the founding of modern science. But, I must insinuate that he provided the material for Locke's empirical philosophy.

The source of this break with the past was the conviction, widely and naïvely held during the seventeenth century, that our observation and reason, when properly exercised, are a sure guide to truth, an efficient key to unlock the mysteries of the material universe. For examples of any such unqualified conviction of truth, we must look to the Middle Ages when an infallible knowledge, derived from the Bible and the Church, was generally accepted; and, again, when in the latter part of the nineteenth century, the biologists, under the leadership of Spencer, Darwin, and Huxley, as confidently believed in the dogma of evolution for the elucidation of the origin and the phenomena of life.

There is abundant evidence that the scientific revolt of the seventeenth cen-

[1] From the symposium on "Natural Philosophy" commemorating the 300th anniversary of Newton's birth which was to have been presented at the New York meeting of the American Association for the Advancement of Science.

[2] *Metaphysical Foundations of Physics*, p. 203.

tury was a deliberate attempt to put into practice Francis Bacon's philosophy of induction. It is not necessary to discuss its principles at length, or the validity of its method; but rather its influence on seventeenth century thought. He tells us how, while yet an undergraduate student at Trinity College, Cambridge, he became disgusted with scholastic Aristotelianism as it was taught, because it had led only to barren disputation, and had through the centuries yielded no valuable fruit. He then, and there, resolved to establish a new philosophy, which would give to man the command over nature he had lost with the fall of Adam. Although his life was embittered by his frustrated ambitions and distracted by his public offices, he continued fitfully to work on his scheme to reform scientific method; but he did not even partially realize his cherished aims until he published, in 1620, the *Novum Organum*, the most important portion of his proposed *Instauratio Magna*.

Bacon, and his disciples, were convinced that the Middle Ages had left to them a legacy of argument on the causes of phenomena and very little knowledge of nature. He awoke their enthusiasm by the blunt statement that philosophy is not a science of things divine or human; it is not even the search for abstract truth; it is rather a practical seeking to improve our condition of life by increasing our power over nature and by forcing her to yield to us her fruits. "All depends," he affirms, "on keeping the eye steadily fixed upon the facts of nature, and so receiving their images simply as they are; for God forbid that we should give out a dream of our imagination for a pattern of the world."[3]

The only source of knowledge we have of the external world, Bacon claims, comes from the impressions made on our sense organs; and the only way we can obtain any guidance in the confused flux of events, which they present to us, is by systematic observation directed by our reason. This new method of induction is the only clue, a *filum labyrinthi*, by holding on to which we may safely and surely trace our way to knowledge and thence to power. "First of all we must prepare a *natural and experimental history*, sufficient and good; and this is the foundation of all."[4] Since we are sadly lacking in any adequate collection of data, the first requisite is to make careful and exact observations of phenomena, to record them, and then to classify them. In time, enough knowledge will have been acquired so that a grasp of the laws of nature will be attained. Nor, should this search for data be left to the whim of the individual; societies should be formed and, under the direction of the ablest leaders, should like a disciplined army go forth to win the battle for knowledge. This proposal to regiment scientists as an army was elaborated in his philosophical romance, *The New Atlantis*.

While it is true that Voltaire and the Encyclopaedists finally gave to Bacon the credit for instituting experimental philosophy, it was really Robert Boyle, followed by Newton and Locke, who implemented his ideas and made the final break with the scientific method of the Middle Ages, which Bolingbroke summed up as having been guided by "an inner sentiment of knowledge."

When Boyle, whose birth coincided with the death of Bacon as closely as Newton's with Galileo's, arrived in London in 1644 after his long exile on the Continent, the only relief he found from the anxieties of the Civil War was in his intercourse with what he termed the *Invisible College*. A number of the leading scholars of London had acquired the habit of meeting once a week to discuss matters of philosophy, and especially to foster experimental science. It was

[3] *Instaur*, Preface.

[4] *Cogitationes*.

largely the influence of these men which induced Boyle to devote his life to chemistry. Later, when the exigencies of war removed these Baconians to Oxford, he joined them; and with their sympathetic cooperation did the major part of his great work.

After peace followed the Restoration in 1660, the *Invisible College* was incorporated as the Royal Society. There is no doubt this Society was formed to carry out practically Bacon's experimental method. Bishop Sprat in his *History of the Royal Society* affirms it, and Sir Archibald Geikie in its *Record* of 1912 states: "The foundation of the Royal Society was one of the earliest fruits of the philosophical labours of Francis Bacon. The experimental method of research which that great man so strenuously expounded in his writings was a vehement protest against the deductive method which till then had been in vogue."

We may question whether scientists have adhered to the inductive method, or have confined themselves to experimentation and the derivation of laws; and we may doubt whether mediaeval science was the slave of deduction—certainly the alchemists, astrologers, and physicians made and recorded a great mass of observations. Yet the founding of the Society was, in a striking manner, the formal beginning of a new scientific era. By its motto of *Nullius in Verba*, its Fellows were pledged not to be bound by the dictates of any school of philosophy; they were to submit all questions to experiment; and they were to express all their findings in the simplest and clearest words possible so that scientific knowledge would become accessible to everybody, instead of being jealously concealed in the mystic phrases of the adept. Perhaps the purpose of the Society is most vividly illustrated by an anecdote. When St. Andrew was selected as its patron, the witty Dr. Petty grumbled: "I had rather have had it been St. Thomas's Day, for he would not believe till he had seen and put his finger into the holes." Such was then the confidence in observation as the key to absolute truth, and the popular translation of the motto had an early beginning.

Before discussing the particular ideas of Newton, it is advisable to state what is generally held to be the nature of the physical universe as it was conceived to be by seventeenth century natural philosophers. According to that mechanistic hypothesis, the cosmos is a vast machine; its individual parts are imperceptible and indivisible atoms whose essential attributes are mass, position, size, shape, geometric order and arrangement; its active principle is innate motion of the atoms, including rest, which operates according to rigorous law quite independently of man's desires and powers. The cause for changes of motion which produce variety was first attributed to collisions of the atoms; but, by the end of the century the force of universal attraction was accepted as the principle of action.

If we except the disciples of Hobbes, who saw nothing operating in the universe but blind chance and fortuitous motions of atoms, the general opinion was that the universe was created by a spiritual being; and its operations, had, once for all, been so exactly regulated by law that subsequent interference was rarely necessary.

This mechanistic conception of the universe was the logical conclusion from the work of that succession of astronomical physicists which began with the publication of Copernicus's *De revolutionibus;* and was the final phase of that Renaissance which reaffirmed the dignity of man's nature, and the importance of his earthly life for itself. There is no doubt of its fundamental break with the beliefs of the Middle Ages which

found in every act of nature the immediacy of God, who created the universe for the use and benefit of man, and who continually regulated it to that end. Law and order did not govern but rather the will of God and, to a less degree, that of man, to the extent that the miraculous was the commonplace; the orderly, the exception. The astrologers taught that the erratic motions of the planets were designed to affect our destiny, and the operations of nature. The alchemists thought prayer a necessary preliminary to the successful outcome of their manipulations. As late as the sixteenth century, Paracelsus, the iconoclast, warns us that prayer and a knowledge of the mystical formulae of the Kabbala were prerequisites for a chemist. To show the extreme view of this immediacy of God and of his purpose in creating the universe, Boyle quotes, with his disapproval, the opinion of a learned divine that, on the Day of Judgment, God would utterly destroy the universe as no longer of any use; mankind having finished its probation. Observation and reason were regarded as but frail supports, in comparison with the infallible revelation of the Bible and the decrees of the Church.

The mechanistic hypothesis was revolutionary rather than original, since it was a revival of the ideas of the Greek philosophers who, with the exception of Socrates and Plato, and to a less degree of Aristotle, derived their ultimate cause from "some inherent law of matter and spirit, which leaves no place for the reality of Ideas, or for a conscious Creator, or for cosmic purpose."[5] Nor, in this respect, is there much difference between the chance results of the atoms of Epicurus rushing fortuitously through the void, and the deterministic *tonos* of Zeno alternately expanding and contracting in an infinitely continuous medium.

We may assume with considerable certainty that, if the Greek culture had persisted and flourished, the discovery of the phenomena and laws of nature would have increased steadily; a clear and simple phraseology would have developed; and natural philosophy would have progressed along mechanistic, or deterministic, lines. Such, at least, the leadership of Euclid, Hipparchus, Archimedes, and others, foreshadowed. But, the collapse of the classic civilization, the intrusion of barbarian hordes, and the impact of the Christian religion with its emphasis on other-worldliness and its reliance on revelation, practically destroyed all interest in systematic enquiry for centuries and, to a large extent, obliterated the scientific knowledge which had been accumulated.

Anyone who has tried to unravel the intricacies of alchemy and astrology during the Middle Ages, can only be filled with wonder that the followers of those sciences acquired as much of useful knowledge as they did. Only the crudest apparatus was accessible to them; no phraseology better adapted to conceal knowledge could have been devised. Dominated by the belief in the influence of the planets on life, and by the search for the magic of the philosopher's stone, a bewildering system of mysticism was built up which distracted the attention from the legitimate purposes of science.

Lastly, a distorted application of Aristotle's metaphysics had, by means of translations and commentaries from Syriac and Arabian sources, been introduced into Europe. This pseudophilosophy of nature gradually became so unquestioned as to be of almost equal authority with the Bible and the Church. Each product of chemical analysis or synthesis was characterized as a compound of different proportions of Aristotle's four essential elements—earth, water, air, and fire. Since there was no agreement as to what these ideal elements represented, there could be no agreement as to the nature or constitution of bodies. Added to this confusion, the alchemists'

[5] P. E. More, *Sceptical Approach to Religion.*

chief interest was concerned with the transmutation of metals, and they chose a philosophic mercury as their principal stuff. By hypothesis, to change one metal into another, say tin into silver, one must detach the specific qualities from the tin which left essential mercury as a residue; then add consecutively the properties of silver. The valuable reagents, acids, alkalis, alcohols, discovered in their operations were regarded as of little importance, except as they related to their absorbing purpose. The major operations for transmutation were repeated distillations and prolonged heating, and the most accepted criterion of transmutation was the right succession of colours. Continual discouragement, arising from the failure to obtain practical results from this logical hypothesis, gradually induced alchemists to seek supernatural help. Some resorted to black magic and sold their souls to the devil in exchange for power; others enlisted the assistance of God by prayer, and by a pious life; but all eagerly sought the mysterious philosopher's stone whose mere presence accomplished the impossible task.

To account for the various attributes of body, recourse was had to Aristotle's category of the formal cause by which potential substance received actual, ideal form. Thus, a body was red because it contained the substantial form of redness; and, frequently, these substantial forms were regarded as entities distinguishable from the bodies themselves. When scientists were confronted with a mystery, such as the levitation of water in a suction pump, they could always rely on nature's abject horror of a vacuum, which Aristotle had declared to be unthinkable, to come to their aid.

Such in bare outline was the prevailing philosophy of nature until the sixteenth century, when a new school of chemistry was founded, under the leadership of the mystical iconoclast, Paracelsus, who introduced the use of chemical drugs, and advocated a greater reliance on experimentation. The major change in philosophy, which these Spagyrists proposed, was the substitution of three hypostatic principles—passing under the names of essential salt, sulphur, and mercury—for the four scholastic elements. The change was of little value, since no one could define what the symbolic principles meant. What notably happened was a bitter controversy between the conservative school of the Peripatetics, which had "not been very solicitous to gather experiments" to prove their doctrines because they relied on pure reason, and the upstart Spagyrists, scornfully dubbed "sooty empirics," who had bleared their eyes, and befuddled their brains, with the smoke of their furnaces.

In fact, instead of clarifying and simplifying science, there followed a deterioration in the whole fabric of its philosophy. Until the sixteenth century, however much scholastic alchemy may have been obscured by an infusion of religious mysticism, and made abortive by a fantastic nomenclature, the alchemists as a body were endeavouring to discover the properties of metals by scientific method; nor were they fraudulently exploiting their work for illicit wealth. But in that turbulent century there developed a radical, and two-fold, change in the aspect of alchemy which caused its efflorescence in the next century as a social and religious menace; and its collapse in the eighteenth century. As a social evil, the transmutation of metals was exploited by individuals, and even by governments, solely as a means of securing unlimited wealth; as a mystic cult, the science degenerated into a grotesque allegory of the sacraments, and of the redemption of man, by an almost blasphemous identification of the philosopher's stone with the Christ, the corner-stone of the Church.

It had become evident that mediaeval science had outlived its usefulness; but it required the effort of a great creative century to bring order out of the chaos. The institutors of the new mechanistic philosophy were Robert Boyle (1627–1691), John Locke (1632–1704), and Isaac Newton (1642–1727); of the three, the chief credit must be assigned to Boyle. Although they were so nearly of an age, he had established his commanding reputation, and had practically won the battle, by the publication of his *Spring and Weight of the Air* in 1660, and the *Sceptical Chymist* in 1661. Nor, was his leadership challenged for thirty years, until the appearance of Newton's *Principia* and Locke's *Essay concerning Human Understanding.*

Thus, thanks to the labors of Bacon and Boyle, Newton had ready made for him a philosophy, exactly suited to his temperament. He was essentially an experimentalist; and he greatly exceeded his predecessors in his faith in experiment rather than in hypothesis, which he finally excluded altogether from the field of science. The mechanistic philosophy afforded him also full scope for his unrivalled mathematical genius, since the problems of position and motion are capable of geometrical formulation. To these two traits, we must add his love of meditation. Apparently, he felt no inclination, or obligation, to make public any of his great discoveries. The mildly critical reception of his letter on the composition of white light so puzzled and exasperated him that he seriously threatened to forsake science; and he carried out this resolve to the extent of publishing willingly no other important work.

What we must rely on, for Newton's personal ideas on natural philosophy, are his letters to friends and scattered comments in his works; but there is one notable exception. In 1704, he published his *Optics,* at the desire of some gentlemen of the Royal Society; although, to avoid disputes he had wished to delay its printing. "My design in this book is not to explain the properties of light by hypotheses, but to propose and prove them by reason and experiments." And, in spite of his professed desire to avoid disputes, he appended two short mathematical tracts in such a way as to accuse Leibniz of plagiarism. As a result of the bitter accusations of Leibniz and his friends, he omitted the tracts in the second edition, "as not belonging to the subject." In their stead, he added at the end of the book, devoted to experiments, "some questions; and to shew that I do not take gravity for an essential property of bodies, I have added one question concerning its cause." It was an odd place for such questions, since they are, in fact, his speculations on the cause and nature of light, gravity, the aether, and radiation, or effluvia. We should never have had his profound reflections on such matters, if he had not been stung to the quick by the Leibnizians, who accused him of promoting atheism and of being as hypothetical in his ideas as others were. Since Boyle had elaborated the mechanistic philosophy in such detail and so sympathetically with Newton's ideas, a short outline of his work will be given as a background for that hypothesis.

Boyle, when a youth, had been converted to the Baconian philosophy by his association with the *Invisible College.* He heard much lip service to the new method, but he also saw little effort to practise its precepts. He determined to devote his life to compare the tenets of the Peripatetic, the Spagyristic, and the mechanistic hypotheses, with experiments, and to foster that one which best stood the test. To carry out this apparently revolutionary idea, he migrated to Oxford in 1654. For six years, he prepared himself for this laborious undertaking. He associated himself with a

small coterie of the ablest scientists in England; he put himself under tutelage to change himself from an amateur to a professional chemist; he equipped laboratories and employed secretaries, amanuenses, and assistants, of whom one was Robert Hooke. As a small army, under his generalship, they were to follow literally Bacon's advice, and compile histories of the physical sciences, which would make accessible, in the simplest and clearest phraseology, all the experimental facts which they would discover, and which they could gather from other sources. With the evidence from these histories, as a beginning, accurate knowledge would be accumulated from which natural laws would evolve, and the most rational philosophy would be developed.

Between the years 1660 and 1673, Boyle published fifteen treatises—experimental histories on the air as a body, on color, on cold, on effluvia or radiant energy, and on many other topics—and exhaustive discussions of the three principal philosophies of nature. The success of Boyle was, I think, without parallel in scope and results in the history of science. His histories were the true beginning of scientific memoirs and of collections of tabulated data; the Aristotelian elements, and the Spagyristic hypostatical principles simply vanished; and with them went the mediaeval conception of substantial forms, *horror vacui*, and the miraculous, as active agents.

As a philosophy of nature, he advocated the acceptance of the atomic and mechanistic hypothesis as recently revived by Gassendi; but he would always remain the sceptic, forbearing to endow the corpuscle with any specific qualities except mass and simple geometric properties; and even these simple metaphysical postulates were to be considered only as guides to thought: "Whether there be any one such body [*i.e.*, corpuscle] to be constantly met with in all, and each, of those that are said to be elemented bodies, is the thing I now question." True to his purpose of creating experimental chemistry, he defined for practical use an element as follows: "I now mean by elements—certain primitive and simple, or perfectly unmingled bodies; which not being made of any other bodies, or of one another, are the ingredients of which all those called perfectly mixed bodies are immediately compounded, and into which they are ultimately resolved."

As cause of action, he could conceive of no other except corpuscular motion and rest, and he deprecated the invention of a substantial form to account for each secondary quality of matter, such as color, tone, temperature. He classed all these forms of radiant energy in the category of effluvia. He hesitated between the idea that an effluvium is caused by special corpuscles expelled from a body, or whether it is the result of motion of bodily corpuscles transmitted through an aether, as pulses or waves, or a combination of both.

The distinction of a primary quality as one which is inherent in body, from a secondary quality which is accidental and serves merely to distinguish bodies, is an artificial and hazardous assumption. It can be justified by the mechanist only as an arbitrary limit he imposes on the problems he chooses to investigate; and that limitation has its advantages.

A little consideration will make clear that the distinction of primary and secondary qualities as a fact of nature is a false one. If Boyle assumed color is the result of special corpuscles, which can differ from the corpuscles of bodies only in the degree of their primary qualities, then he is, in fact, postulating color as an entity, or substantial form. If he chose to postulate color as the effect of motion in an aether, in what manner does aetherial motion differ from the primary quality of a bodily motion,

or the aether itself from a substantial form. Nor is this an academic question. Are not our modern hypotheses of electrons as body, of wave mechanics, of quanta of energy, of packets of light, a revival of mediaeval substantial forms of occultism? So difficult is it for scientists, who profess to rely on observation, to refrain from creating and materializing an occult entity to account for what they can not comprehend. They too often forget Maxwell's sound dictum that the atom, however disguised, has all the ear-marks of being man-made.

Boyle made a complete cleavage between phenomena of the material and spiritual worlds. The Christian God was the creator and ruler of both; and man, as a unique creation, was endowed with such powers of observation and reason as to understand the purpose of both to a limited degree. The material world was created to operate under rigorous mechanical laws unaffected by man's desires, at least for the most part; but Boyle was sceptical as to the absolute rigor of these laws, and credited miraculous intervention as well as slight variability. Instead of promoting atheism, the mechanistic hypothesis, if rightly interpreted, should be a strong support of the Christian religion, since God revealed his nature and his purpose towards man through his ordained laws of nature.

But, in Boyle's conception, since the spiritual nature is nobler than the physical, and moral character more valuable than mechanical power, so science is necessarily of a lower degree than religion. Therefore God had given to man a more authoritative revelation of his purpose of creation in the Bible than he had in the Book of Nature, and to implement that revelation he did not hesitate to change physical law temporarily by fiat or because of the legitimate petitions of men.

Although man, being finite in his apprehension, can not grasp the whole scheme of things entire; yet he can attain a real knowledge of phenomena and their efficient cause, and even to a limited degree the final cause and purpose of the creation. He apparently had no doubt that experimental observation revealed the phenomenal world as it really is. It is a mournful commentary, that it has taken us some centuries to recognize the paradox of science that the more accurate our apparatus, and the more carefully our observations are made, just the more certain and evident our errors will be; so that at last we have formulated, with some complacency, the principle of uncertainty as a *law* of nature.

Nor did Boyle hesitate to trust to the same method of obtaining truth in the spiritual world. He was a leader in the Deistic branch of the Anglican Church which followed a *via media* between the Romanists who could not err, and the Calvinists who would not. While he denied the infallibility of the Bible and of the Roman Church, and the inerrant logic of Calvin, he agreed with the Deists that those matters necessary for salvation are so few and so simply stated in the Scriptures that we can apprehend them. Alas again, time has proved that even what is necessary for salvation is a matter of infinite dispute.

The great productive period of Boyle, 1660–1673, coincides exactly with the years of Newton's life, when, as he remarked, his mind was most active, and his inventive genius at the height of its creative power. He entered Trinity College in 1660; he spent from August 1665, to March 1667 at Woolsthorpe, where he invented the calculus, discovered the laws of gravitation and the composition of light; and, in February, 1672, he sent to the Royal Society, his *Letter*, containing his new theory of light and colors—"being in my judgment the oddest, if not the most considerable detection, which hath hitherto been made in the operations of nature."

It will hardly be denied that the philosophic bias of a man is largely determined by his temperament, and that his success is dependent on its being in sympathy with contemporary ideas. If we can impute Boyle's influence to the fact that, as the first modern experimentalist, he was in accord with the prevailing "climate of opinion," we must class Newton as a supreme example of that type of mind. While Boyle was diffuse in his interests, Newton was concentrated and, having begun to meditate on any subject, he never let it lapse until he had wrung out of it all he could. Not only was he a greater experimentalist than Boyle, but he also was endowed with an incomparable mathematical genius. But he used mathematics only as a tool; as an end in itself, he considered it a dry and barren subject, and tending to involve one in useless speculation, or hypothesis. In his conviction as to the sterility of scientific hypothesis, he far exceeded the precepts of Bacon, and the practice of Boyle. Nothing angered him more than to accuse him of introducing occult causes in the *Principia*. As an answer to this charge by the Cartesians, he retorted that his system was founded on experimental evidence, and developed with mathematical rigor; and for that reason, "the hypothesis of vortices is pressed with many difficulties."

Not only did Newton believe that the first commandment of science was that theory must be based on experimental facts, but he also was ready to abandon his cosmic theory without hesitation if it lacked that support . . . ; "After he [Molyneux], and Mr. Graham and Bradley had put up a perpendicular telescope at Kew to find out the parallax of the fixed stars, they found a certain nutation in the earth which they could not account for, and thought destroyed the Newtonian system—M. told I. N. as gently and tactfully as he could—But all I. N. said in reply was, 'It may be so, there is no arguing against facts and experiments.' "[6]

Because of Newton's discovery of the universal force of gravitation, and the unparalleled influence of his *Principia*, he is popularly, and erroneously, regarded as the dictator of a universal machine ruthlessly governed by rigorous geometric laws and in which man is reduced to be a puny and impotent onlooker. If, however, we examine this work critically, we shall find that, except for a short and formal statement of abstract mechanical principles as an introduction, the body of the work is an exposition of Bacon's inductive philosophy as it was experimentally developed by Boyle.

Newton, in his *Preface*, makes his purpose clear that he is considering a very restricted category of problems; namely, those which obviously involve only position, motion, and a mechanical force, all of which are quantitatively expressible in geometric propositions and theorems. Furthermore, in agreement with this purpose all other qualities of body are abstracted excepting mass, a numerical coefficient equal to the ratio of the mechanical force, and the acceleration it produces.

Newton expressed his purpose with such care that the passage is quoted: "Since the ancients (as we are told by Pappus) made great account of the science of mechanics in the investigation of natural things; and the moderns, laying aside substantial forms and occult qualities [Note the influence of Boyle], have endeavoured to subject the phenomena of nature to the laws of mathematics, I have in this treatise cultivated mathematics so far as it regards philosophy." Taken by itself, this statement would justify the idea that he embraced the whole of objective phenomena; but not so, if we read further:

[6] *Portsmouth Papers.* Memorandum by Conduitt.

"We consider chiefly those things which relate to gravity, levity, elastic force, the resistance of fluids, and the like forces, whether attractive or repulsive; . . . to this end the general propositions in the first and second books are directed. In the third book, we give an example of this in the explication of the System of the World; for by the propositions mathematically demonstrated in the first book, we there derive from the celestial phenomena the forces of gravity with which bodies tend to the sun and the several planets. Then from these forces, by other propositions which are also mathematical, we deduce the motions of the planets, the comets, the moon, and the sea. I *wish* we could derive the rest of the phenomena of nature by the same kind of reasoning from mechanical principles; for I am induced by many reasons to suspect that they may all depend upon certain forces by which the particles of bodies, by some causes hitherto unknown, are either mutually impelled towards each other, and cohere in regular figures, or are repelled and recede from each other." How far he succeeded in his "wish" to apply mechanical principles to the phenomena of light, will be discussed later.

Shortly after the *Principia* was published, Newton was charged with having, himself, introduced occult qualities, or substantial forms; and, more seriously by Leibniz, that he had encouraged atheism, because his God was at most merely an indefinite being who created an universal machine, which was self-acting and needed but a mechanic to keep in repair. To the charge of occultism, he answered, that his system involved only such principles as *Vis inertiae*, gravity, fermentation, and cohesion. These are not occult qualities, as were substantial forms and vortices, because they are observable phenomena. Their causes are occult and, for that reason, speculation in regard to such causes had been excluded from his work.

As to the charge of atheism, it should be remembered that Hobbes had aroused a great controversy in England; such leaders of science, as Boyle and Newton repudiated his materialism as atheistic, and were sensitive lest their ideas should be confused with his: hence the *Boyle Lectures against Atheism*, and Newton's *General Scholium*. It also should be remembered that Leibniz was then smarting under the accusation of plagiarism. Newton was certainly not an atheist, but his views on Christian dogma are puzzling. All his life Newton remained a professing member of the Anglican Church. He was an incessant reader of the Bible, believed in a spiritual and personal God, and in his miraculous interference in man's behalf. Yet he was privately a Unitarian, and rejected the doctrine of the Trinity, on the ground that what could not be understood was not necessary to be believed. This conflict between Christian dogma and practice was frequent at that time, and must always result from an attempt to rationalize religion.

Newton was emphatic that the universe was created by a spiritual Agent, who, having planned and instituted adequate mechanical laws, had little need to interfere in their future operation. Thus, to investigate these laws was to learn in part the purpose and plan of God; but, his laws and relations with man are revealed in the Bible.

Our knowledge of objective phenomena, Newton thought, was brought to us by mechanical motion to the sense organs, and from them transmitted along the nerves to the brain. The translation, and interpretation of these messages were made by an immaterial entity, spirit, or soul, located in the brain and which, following Henry More, he termed the sensorium. This association of an immaterial entity and of body was a frequent device. Descartes placed the mind in the pineal gland; Boyle regarded the union of the soul and body as the great-

est of mysteries, to be accepted only on faith.

Before Bentley published his Boyle Lectures, he wrote to Newton that he had supported his argument for the existence of a Divine Creator on evidence from the *Principia;* and he asked whether the universe could have been created by natural powers.

Newton answered: "When I wrote my treatise about our system, I had an eye upon such principles as might work with considering men, for the belief of a Deity." He then answers Bentley's question, by first postulating matter to be uniformly distributed through all space in the beginning, as the atheists had supposed, and all the particles to be mutually attractive. If space is finite, he thought all the matter would drift to one centre and form a great spherical mass. If space is infinite, there would be no centre and some matter would fall to one point, and some to another, and thus make the stars.

It is evident that Newton had given little thought to the problem, for he became critical of his opinions as the correspondence continued. Finally, after many attempts, he concluded that the postulate—afterwards assumed by Kant and Laplace—was "inconsistent with the hypothesis of innate gravity, without a supernatural power to reconcile them; and therefore it infers a Deity." It was of this correspondence, that Dr. Johnson remarked: "Even the mind of Newton gains ground gradually upon darkness."

Later, to meet the accusation of atheism, he made his confession of faith in the *General Scholium* to the second edition of the *Principia:* "This most beautiful system of the sun, planets, and comets could only proceed from the counsel and dominion of an intelligent and powerful Being. . . . As a blind man has no idea of colours, so have we no idea of the manner by which the all-wise God perceives and understands all things."

All the bodies forming the universe are, according to Newton, composed of discrete atoms, which are endowed with the primary geometric qualities, first proposed by Galileo. But he also endowed bodies with an additional quality, a fact which historians have overlooked. His third definition of motion reads: "The *vis insita*, or innate force of matter, is a power of resisting, by which everybody, as much as in it lies, *endeavours* to persevere in its present state. . . . This *vis insita* may, by a most significant name, be called *vis inertiae*, or *force of inactivity.*" The acceptance of a vitalistic principle, perhaps, was influenced by Henry More, whose philosophy was based on the necessity of spiritual forces in the operations of the physical world.

Newton had made the supreme discovery of universal attraction, with which to replace mere motion as the active agent of phenomena. But, he was deeply impressed by the lack of evidence of a repelling force to give balance and stability. He even went so far as to suppose the existence of a most subtle Spirit which pervades and lies hid in all gross bodies. In seeking for an illustration of this Spirit, he notes the fact that "electric bodies operate to greater distances, as well *repelling as attracting* the neighbouring corpuscles." Then he cautiously adds, we have not the experimental evidence "which is required to an accurate determination and demonstration of the laws by which this *electric* and elastic Spirit operates."

This invocation of a subtle Spirit to explain any perplexing phenomenon is a time-worn custom. Once a personal demon or angel, it passed into the form of a philosopher's stone or a universal elixir; then, it reappeared as an exhalation or effluvium of a mysterious nature. When Boyle proved that air was no more occult than any other body, effluvia were stripped of their spiritual powers, and became aethers which accomplished their functions by mechanical action.

Newton was a convert to the Boylean aether, and wrote to him, his idea of its nature: "I suppose that there is diffused through all places an aetherial substance, capable of contraction or dilatation, strongly elastic; and, in a word, much like air in all respects, but far more subtile. I suppose this aether pervades all gross bodies, but yet so as to stand rarer in the pores than in free spaces; and so much the rarer, as their pores are less [or the bodies are denser]." To understand the better the enthusiasm aroused by the substitution of a gaseous and corpuscular aether in place of more apparently mysterious Spirits, we should recall the equal relief caused by Maxwell's theory of electrodynamics, and the change of a gaseous, into an electromagnetic, aether.

When Newton allowed himself to relax the limitations he imposed on the scientific method, he was an imaginative and daring speculator. Of the many illustrations he cites in a private letter to Boyle, to show how he would use the aether to explain phenomena, those for gravity and light will suffice.

Newton first devised an experiment to prove that gravity is not an innate quality of matter. He found that the period of a pendulum was quite independent of the kind of matter composing its bob; and he concluded that the attraction of the earth was independent of any specific properties of the corpuscles. He then enquired into the possibility whether the aether described above could, by its pressure, cause attraction. He, first, assumed that the aether, between two bodies, progressively rarefies as they approach each other. By an explanation too long and intricate, and I may add too vague, to be quoted, he satisfied himself that the pressure of such an aether would account for their attraction; also, it would produce a repulsion, when they approached very closely to each other. In justice to Newton, I quote from his letter: "The truth is, my notions about things of this kind are so indigested, that I am not well satisfied myself in them; and what I am not satisfied in, I can scarce esteem fit to be communicated to others, especially in natural philosophy, where there is no end of fancying."

It is often stated that Newton, by adopting the corpuscular theory of light, retarded progress in the subject for a century. But, it should also be remembered that he carefully considered the possibility of its propagation by aetherial waves. In order to obtain a relation between the properties of a gas and the velocity of wave transmission through it, he made a careful determination of the velocity of sound through air, and discovered the law that $V = \sqrt{e/d}$. Since the velocity of light was then computed to be 700,000 times that of sound, he concluded that "the elastic force of this medium, in proportion to its density, must be above $700{,}000^2$ times greater than the elastic force of the air is in proportion to its density." It was not the staggering properties of such a gas which made him discard the wave theory, but rather the impossibility of explaining the newly discovered polarization of light as a property of a compressional wave. The later assumption of a transverse wave in a gas may have solved the problem of polarization, but it was ultimately the death of the luminiferous aether. Such violent assumptions, to explain a particular phenomenon, were absolutely repugnant to him.

Having decided in favor of the corpuscular theory, Newton was free to speculate on its effects. A multitude of light corpuscles occupy the pores of a body and, by their motion, agitate its corpuscles to cause the phenomena of heat. When they are expelled from a body, they travel through space as rays of light. If they fall upon the retina of the eye they cause a vibration in it which proceeds along the nerve fibers, and are

translated by the sensorium as color—the longest vibrations as red; and the shortest as violet. Also, these rays of light set up waves in the gaseous aether which travel faster than the rays and give to them alternate fits of easy refraction and reflection when they strike a body.

Since light, aetherial, and bodily, corpuscles differ only in degree, and not in kind, there should be a mutual gravitational action which will deflect a ray of light as it passes close by a body. Are not, he asks, gross bodies and light convertible into one another? Such a process "is very conformable to the course of nature, which seems delighted with transmutations," as Mr. Boyle proved when by frequent distillations he changed water into fixed earth. These illustrations may show what Newton could add to the metaphysics of nature, and I esteem him as fertile in fanciful speculation as, for example, Sir Arthur Eddington.

I have, for the most part, discussed what Newton would have slightingly termed his hypotheses; his greatest contribution to the philosophy of science was made in 1673, at the beginning of his career. I am referring to his *New Theory of Light and Colours.* I had often wondered why he, so persistently reticent, should then boastfully claim to have made the greatest of scientific discoveries. Yet, he must have known that his discovery of the law of gravitation, as a new fact, far out-weighed that of the nature of white light. I am convinced his enthusiasm was aroused because he realized that he had for the first time brought one of the secondary qualities of matter into the field of geometry and mechanics; that he had given final authority to empirical science; and that he had determined the limits of scientific, or at least quantitative, experimentation. Since I dwelt on this idea at some length in my *Life of Newton,* I shall now limit myself to a short extract from that argument.

Newton, in the first place, refused to give an hypothetical explanation of color and, in the second place, he refused to adopt the psychologic, or subjective, sensation of color as a criterion for physical, or objective, phenomena of light. To him, as a physicist, a primary ray of light was one which had a definite angle of refrangibility, and could not be decomposed by a prism, irrespective of what sensation of color it might cause. Hooke's classification of red and blue as primary colors, because, when mixed, they gave the sensation of white, were no more primary according to Newton's mechanical criterion than were any other non-dispersive colors; nor was that *white* physically the same as the *white* of the continuous spectrum. This may seem to be a trifling difference, but it involves the essential problem of what constitutes the scientific method, if it be defined as an objective investigation of phenomena. To the physicist, the problem ends when light energy is physically absorbed by retina; for the psychologist the problem begins with that absorption. What happens by which that energy is translated into color is a process to which science can give no clue.

A short discussion of the effect of the mechanistic philosophy, as a whole, on subsequent thought is the proper conclusion of this essay. Quoting from Basil Willey's *Seventeenth Century Background:* "Though there is no diminution in the volume of praise which is bestowed on the giants of the seventeenth century—'the century of genius'—there is no longer the old tone of expansive optimism, the glad sense of final escape from error. Though no one denies the extent of our gains, it is more often of our losses that we are now reminded."

Of our losses, Professor Whitehead writes:[7] Nature according to the mech-

[7] *Science and the Modern World,* Ch. III.

anistic philosophy "is a dull affair, soundless, scentless, colourless; merely the hurrying of material, endlessly, meaninglessly. However you disguise it, this is the practical outcome of the characteristic scientific philosophy which closed the seventeenth century. No alternative system of organizing the pursuit of scientific truth has been suggested. It is not only reigning, but it is without a rival. And yet—it is quite unbelievable. This conception of the universe is surely framed in terms of high abstractions, and the paradox only arises because *we* have mistaken our abstractions for concrete realities. . . . Thereby, modern philosophy has been ruined."

I agree fully with Professor Whitehead that the mechanistic philosophy, as it has been enlarged and developed since the seventeenth century, has, on the whole, been disastrous to society; and especially to religion. But, on whom, is to be placed the blame; certainly not on its institutors? No, the blame rests squarely on their successors who, either ignorantly, or wilfully, extended it to disciplines and fields of thought which Bacon, Boyle, and Newton would have utterly rejected as mechanical or material. They omitted from the science our sense perceptions of color, scent, sound, because such sensations are not mechanical. They, also, first recognized that such sensations are preceded, even if not caused, by phenomena involving objective body, force, and motion, or kinetic energy as we now class them together. They, and most physicists since then, have restricted themselves to the study and applications of this mechanical energy with eminent success. Nor, is it surprising that they, quâ mechanists, class certain qualities as primary for their purpose, and others as secondary. Is there any other method of studying a given subject except by such abstractions? Is not a theologian permitted to treat the Christian religion, and to regard other faiths as of secondary importance? It may be unfortunate to be limited in capacity but, perhaps, the persistent attempts of metaphysicians to embrace all knowledge in a single frame is a part cause of their incoherence and ambiguity.

In its own field, the science of mechanics has been so successful and so exact that it has been extended to other sciences verbally, but not factually. It was not the mechanistic physicists who made the mechanistic philosophy "not only reigning, but without a rival." It was the biologists, who have pictured life as a mechanical evolution of matter; the psychologists, who have identified sensation, thought, and the soul, with mechanical energy; the sociologists, who have tried to substitute rigorous social laws for individual responsibility and free-will; and who have degraded Christian ideals of other-worldliness to a humanitarian hedonism. It is these scientists and monistic metaphysicians, who have ruined modern philosophy.

CHINA AND AMERICA AGAINST SOIL EROSION

II. LOSSES AND GAINS

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In the first part of this paper, which appeared in THE SCIENTIFIC MONTHLY for May, 1943, we have shown from observations and experiments of the senior author what has led to destructive erosion and damage by floods. These facts were found near the headwaters of the Fen River in Shansi, China. We have also presented evidence from printed Chinese records studied and translated by the junior author regarding the area of the sacred mountain Wu-t'ai Shan, about fifty miles to the east, and other areas in the northern part of the province, which traces the course of land use through 1,800 years. In spite of once successful measures for conservation, deforestation of slopes and erosion of cultivated fields have irreparably damaged large areas and induced destructive regimens of the streams.

Similar experiments were carried out and records examined for other areas in the same province which are now to be discussed.

SIMILAR REPORTS FROM OTHER AREAS

Passing southward to the west of the Fen River we next consider three adjoining districts with steep, mountainous topography. Lan Hsien extends on both sides of the divide between the Fen and Yellow Rivers, while Hsing and Fang-shan Districts are west of the divide. The rainfall is in general convectional in type, and is heavier than in most parts of Shansi because of the altitude, 9,000 feet (2,870 meters) at Kuan-ti Shan. Loess soils cover elevations up to 5,000 feet, above which mountains are of granite weathered into residual loamy soils very subject to accelerated erosion.

Forests formerly covered large areas, as evidenced by a record dated in 1557 in the gazetteer of Hsing Hsien issued in 1763, which states that before the time of Chia-ching (1522–1566) mountain forests were flourishing and dense in the drainage basin of the Wei-fen River, which rises to the east in Lan Hsien District and flows with several tributaries through Hsing Hsien. In the Fang-shan District considerable areas are still forested, as found and studied by the senior author in 1925. Remnants of the original forest cover lie between the 6,000 and 8,500 foot contours on Kuan-ti Shan. The largest tract consisted of a dense stand of poplar (*Populus,* sp.) and birch (*Betulus,* sp.) which apparently succeeded a coniferous forest entirely cut off at some time in the past. At similar elevations forest stands of pure larch (*Larix dahurica*) were found and mixed stands of larch and spruce.

In Fang Shan District observations showed that the loess cover is cultivated in every locality and on every slope where a man can keep his footing. Above 6,000 feet possible farming land is left to forest not because of low temperatures, but because of the ravages of wild boar on root and other crops. Cutting of the forest in a small way has apparently been carried on for a long period of time, but except in rare instances the soil has not been cleared and cultivated. It is significant that in the forest areas studied no soil erosion was going on, that the water of streams was clear at all times, even after the most violent rains, while under observation from July 26 to August 19 of 1925, when stream flow was being measured. Stream-flow changed little dur-

ing and following these heavy thunderstorm rains; the flow contained bits of humus material in suspension which scarcely discolored the water, but mottled it with blackish particles. Filtering the water following storms gave negative results for silt. Despite the heavy rains that fall in this region (60.3 mm, or 2.37 inches in eleven hours, 40.7 mm, or 1.60 inches, in 10 hours, and 12.5 mm, or 0.5 inches, in one quarter hour were observed), soil erosion is lacking and stream-flow is well regulated (4.8 inches in twenty-four hours was the greatest observed rise in level); whereas in the Tung Chai area such rains on cultivated slopes produced raging torrents, which tore soil and rock out of flanks of mountain sides and carried such debris headlong down water courses as we observed during rainy seasons of 1924 and 1925 and reported elsewhere.[27]

Historical records indicate that such accelerated erosion is of long standing. The gazetteer of Hsing Hsien already cited says: Now (1557) (in the drainage area of the Wei-fen River), the opening up of virgin soil by cultivation is daily extended, and the peaks and slopes are all bared of trees and other covering. Of Lan District in particular, which contains the upper part of this drainage area, its gazetteer dated in 1730 states that even the good fields are eroded by annual heavy rains till they are all cut into watercourses and gullies, leaving an inch of earth difficult to cultivate.

This gazetteer also reports 21,819.62 acres (1,442 ch'ing 14.3 mou) of land in default for grain tax of 6,542 taels, found by investigation to be waste land with no discoverable owners or slopes seriously eroded by water. In 1657 (fourteenth year of Shun-chih) the second month the Shansi governor secured remission by edict of taxes on 1,783 acres (117 ch'ing 85 mou) of deserted land, which had been injured and rendered useless, and in the eighth month of the same year exemption for 18,185 acres (1,201 ch'ing 92.35 mou) of additional deserted land.

That the connection between forest destruction, cultivation of the land and erosion and destructive floods was not unknown to the Chinese nearly four centuries ago is made clear by a passage in the gazetteer of Hsing District, dated in 1557, which says:

> The south side of the city of Hsing Hsien is a few hundred feet from the Wei-fen River, which rises in the mountains of Lan District thirty miles away and has a number of tributaries. Before the time of Chia-ching (1522–1566) mountain forests were flourishing and dense, and although there were heavy rains, still they largely soaked in and were impeded (in runoff), and the river was not a plague. Now the opening up of virgin soil by cultivation is daily extended, and the peaks and slopes are all bared of trees and other covering. Every summer and autumn the water rushes down steep slopes without the slightest obstruction or storage. Therefore its force becomes more angry in its rapid flow, so that the dyke and bank are made to fall in ruins and people's dwellings and the enclosing wall of the South Gate are completely washed away. People in the east and west enclosures have also moved out to avoid calamity.

The walls were repaired in 1555–1556, but in that year or the next the river dyke collapsed to the great danger of the city, and in 1557 Wang Wan called a conference on the matter. Again in 1822 (the second year of Tao-kuang) the river suddenly overflowed after soaking rains, damaged the southeastern corner of the city, destroyed several hundred feet of the city wall and swept away several hundred dwellings (chien). Of the three streets of the East Suburb only one was left; and as to the earth wall and the lane, even their former location could not be made out. The city wall was rebuilt with the aid of 1,000 ounces of silver granted by the Emperor.

Chinese writers in this area report that differences in the use of land have resulted in great differences in regimen of stream-flow, which is regular in forested areas but becomes irregular and destructive where forests have been removed and soil is cultivated and eroded. In the

[27] Part I. p. 400 *f.*

latter case damage to soils leading to their abandonment for cultivation is recorded as an additional result of unleashing of forces of erosion in mountainous regions. K'o-lan Department, lying north of Hsing and Lan Districts and west of Tung Chai, shows similar conditions to these.

The record of land taxation in its gazetteer (1881) shows taxes remitted for over 19,200 acres of land injured and deserted, being more than half the total on the tax list, in the years 1647, 1653 and 1853. Meantime land amounting to 18,626 acres had been newly brought under cultivation by 1728. New land in cultivation had been substituted for most of the abandoned fields.

The record of Yung-ning Department, adjoining Fang-shan District on the south, in gazetteers of 1703 and 1881 is similar to that of Hsing District, with remnants of forest and destructive floods, first mentioned in the Hung-chih period (1488–1505).

The District of T'ai-yuan, a few miles south of the present capital of the Province, lies mostly in the plain of the Fen River, with a steep mountainous area on the west. Here as elsewhere in Shansi the rainfall occurs as heavy thunderstorm downpours in the summer. The soils are alluvial in the plain, having been derived from erosion of the loess at the lower elevations and of residual soils of slopes formerly forested but cleared and cultivated until abandoned.

There is evidence in gazetteers of forests on mountains to the west and southwest of the city of T'ai-yuan Hsien within a few miles of the river. The plain has long been cultivated, in part under irrigation. Records contained in the gazetteer issued in 1826 include accounts of numerous destructive floods beginning in the thirteenth century A.D. These floods through the centuries have entered the city of T'ai-yuan Hsien, silted up and destroyed buildings, carried away dykes and silted up canals for irrigation and the city moat. A stone dyke built in Ming times (Cheng-te period 1506–1521) and repaired in 1528 (the seventh year of Chia-ching) was breached and partly washed away in the first years of Ch'ien-lung (1736–1795), the water forming three sand rivers up to the east and north suburbs of the city. Another breach was produced in 1752 and 1753 (the seventeenth and eighteenth years of Ch'ien-lung) with still greater injury to the west and south suburbs and to neighboring fields and houses. In 1287 (the twenty-fourth year of Yuan-Shih-tsu Chih-yuan) the river overflowed and damaged crops. In 1501 (fourteenth year of Hsiao-tsung Hung-chih) the

DENSE POPLAR STANDS

WHICH FURNISH EXCELLENT MATERIAL FOR MATCH STOCK. A MATCH COMPANY ESTABLISHED ITS HEADQUARTERS IN THIS FANG SHAN AREA OF SHANSI FOR THE EXPLOITATION OF LARGE AREAS OF THIS TYPE OF FOREST.

GENERAL VIEW OF CUTTING IN A FOREST OF LARCH, FANG SHAN AREA
SHOWING THE TIMBERS PREPARED READY FOR PACKING OUT ON MULE BACK TO THE VALLEY.

water of the Fen rose more than forty feet. Of the villages and hamlets along the river banks the houses and growing grain were carried away or submerged almost altogether; and a great famine followed, we are told. Again in "the sixteenth year of Mu-tsung Lung-ch'ing" (1582? perhaps an error for sixth, 1572) a great famine is reported when the Fen River overflowed its banks, carrying away and inundating growing grain on both east and west sides. In 1683 (twenty-second year of K'ang-hsi) floods in autumn carried away and inundated almost completely the crops of standing grain.

In 1725 (the third year of Yung-cheng) flood waters from the Fen were four or five feet deep over level land, crops were swept away or inundated and dwellings in certain named villages collapsed in ruins. In 1748 (the thirteenth year of Ch'ien-lung) an overflow of the Fen when wheat was ripe emptied all the heads in one evening. In 1768 (the thirty-third year) with heavy rain the Fen overflowed and a torrent from Wind Valley (Feng-yü) ruined over 400 feet of the city wall. In 1775 (the fortieth year) water from Wind Valley swept away and inundated several villages southwest of the city, both fields and dwellings, and inundated Yin-Kung Shrine. And so the tragic account goes on for district after district of Shansi.

The gazetteer of Ch'ing-yuan suburban district (now Ch'ing-yuan Hsien, southwest of T'ai-yuan Hsien), for 1882 also shows forest remnants, as temple and monastery forests, and records many damaging floods of the Fen and other rivers, also two shifts in the bed of the Fen River in 1870 and 1872. Blocking of canals with silt is frequently reported in the records.

Hsu-kou District east of Ch'ing-yuan across the Fen River lies in the plain. Its gazetteer of 1712 records no trees but willow plantings around moat and dyke. Many destructive floods over the plain are reported, along with stoppage of canals with silt and covering of land with mud and sand, and the drying up of an irrigating canal in spring and summer. Continuing destructive floods are reported in the gazetteer of 1881. This work also reports the entire disappearance of groves of willow trees formerly

growing about the earthen altars dedicated to spirits of the land and grain and to those of woods, cloud, thunder and rain.

In this area we find deforestation, combined with extensive damage to agricultural land, to irrigation canals and to other works of man by torrential floods originating in deforested mountains.

T'ai-ku District lies a little to the east of the Fen River, its western part in the plain and its eastern part hilly and mountainous. Rainfall occurs in great part as thunderstorm downpours, with occasional gentle rains. Soils are made up chiefly of a deep mantle of loess which is very fertile if watered with rains, but also very susceptible to rapid gully erosion when cultivated on slopes without terracing.

The gazetteer of T'ai-ku District published in 1855 records past deforestation of various mountains and hills. Regarding a mountain called Pine Range (Sung Ling) ten miles southeast of the city it quotes the Wang gazetteer (1739) as saying: "The mountain is high, pines flourishing; in the morning clouds rise like towers; one of the ten (famous) views. Afterwards it was sought out with axe and hatchet; the forest of pines disappeared and the mountain was left bare; the clouds also had no place to rest on. Now only the empty name remains." (See also poem in 8/21 b f.). Of the Dragon Hills (Lung Kang) five li NE. of the city, it says: "One of the ten famous views. In late Ming and early Ch'ing dynasty times thick stands of pine and cedar grew on the hills. Cutting for timber went on rapidly, and the hills were gradually denuded of trees and herbage, and now nothing is left on the small hills, and all are bare of trees."

Regarding the behavior of streams and rivers it quotes another earlier gazetteer (1795):

> Irrigation in the southeast is easy, in the northwest more difficult, for using water of the plain is easier, but waters from the mountains harder; because great rivers, although they may keep their names, are as blotted out in fall and winter, and in summer when it rains mountain torrents rise suddenly; if there is nothing to withstand the wild waters, they overflow the land

VIEW OF LARCH FOREST WITH CUTTING IN PROGRESS

FANG SHAN AREA OF THE PROVINCE OF SHANSI. THE LARCH OCCURS AS PURE STANDS IN GROUPS. SPRUCE AND BIRCH ARE INTERMIXED IN THE DAMPER AREAS.

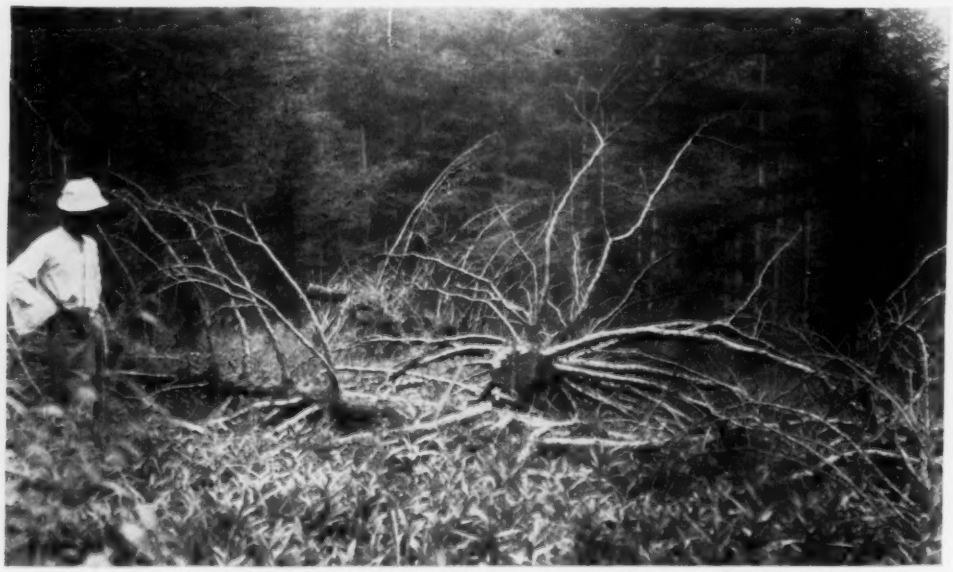
in all directions; and if there are no dykes to lead and collect the flood waters, they quickly cut gullies and go straight on, and are lost for irrigation. Therefore the difficulty of profitable use of water is nowhere greater than in Shansi, both as to high and low water.

The adjoining district of Ch'i Hsien has somewhat similar records, both of forest remnants on certain mountains and of destructive floods from 1544 on. The same is true of Wen-shui District, to the west across the Fen River, in which the first flood reported was in 1491, and shiftings in the course of rivers repeatedly occur. There in 1657, 2,812.67 acres (185 ch'ing 89.982 mou) of land were exempted from taxation because carried away by a river or occupied by water. Similar records come from Fen-yang District (Fenchowfu) to the south of this and from P'ing-yao District next southeast across the Fen. Farther south along the Fen River we find similar records in gazetteers of the Districts of Chieh-hsiu, Ling-shih, Hung-tung, Lin-Fen and Chi-shan.

The District of Ch'in-yuan lies near the headwaters of the Ch'in River, which drains a large portion of the dissected highland of southeastern Shansi. The mountain massif reaches altitudes of 7,000 feet in the highest points; the general elevation of the tops of the ridges varies between 5,000 and 6,000 feet. The valleys are generally steep-walled, and the face of the landscape is conspicuously dissected. The floors of the main drainage system in the upper part of the watershed are 500 to 1,000 feet below the general plain of the higher ridges. A high ridge along the west side of the district separates this drainage from that of the Fen River.

The rainfall comes mainly as convectional summer thunderstorms, with occasional gentle rains.

The soils in this district are chiefly residual, being derived from calcareous formations bearing coal seams and hard shales. Within temple forests soils with normal profiles mantle the country rock,



DETAILED CUTTING, SHOWING HOW WASTE TIMBER IS LEFT IN TREE TOPS

SUCH KNOTTY MATERIAL DOES NOT PAY FOR TRANSPORTATION BY PACK MULES. MUCH WASTE OF TIMBER OCCURS HERE IN THE FANG SHAN AREA, IN SPITE OF THE GREAT NEED OF TIMBER IN CHINA, PARTIALLY RESULTING FROM THIS WASTE.

A CUTTING OVERRUN BY A SLASH FIRE IN THE FANG SHAN AREA
NOTE HIGH STUMPS THAT ARE SERIOUS WASTAGE OF TIMBER. LABOR AND MANAGEMENT PROBLEMS WERE RESPONSIBLE FOR HIGH STUMPS IN THIS CASE.

but the soil profile is generally eroded away to parent material in old cultivated areas. Soil accumulates in benches behind roughly horizontal bands of vegetation, and is there still cultivated in much reduced area.

Small tracts of forests were examined by the senior author in 1925 and are mentioned in gazetteers of Ch'in-yuan District (1730, 1881). These have been preserved by near-by villages, sometimes acting in concert. The region is generally cultivated, except for the scattered forests, but as much as 40 per cent. of the region is now in barren slopes, which generally show evidences of former cultivation. Where abandoned, the slopes are coming back to a tree cover, but very slowly, for grazing by sheep and goats tends to keep the vegetation down.

In the northern part of the district, at T'sung-tzu Yü, the senior author made a study of a forest about sixteen acres in area which had been protected and managed by the village, whereas surrounding areas had been cleared and cultivated and were seriously eroded. This forest of pine (*Pinus Massoniana*) lies between the contours of 4,500 and 4,800 feet; the forest floor is covered with a flourishing understory of shrubs. Doubtless this growth owes its preservation from fuel gatherers to easily accessible seams of coal in the surrounding region.

Records of runoff were made for duplicate plots in the forest and on a homologous but denuded slope near-by, in twenty-three storms covering a period of eighteen days and totaling a fall of 12.1 inches (307.5 mm) of rain. In the forest plots the percentage of runoff for the total of twenty-three storms was .126 per cent., where the greatest runoff coefficient for a single storm was 0.284 per cent. From plots in fields denuded by erosion, the average runoff coefficient of total rainfall was 7.2 per cent. and the greatest measured for a single storm was 19.85 per cent. A most significant finding was that no erosion took place in the forested

LOADING HEWN TIMBERS

ON A MULE TO BE TRANSPORTED FROM THE FANG SHAN AREA DOWN SLOPE TO THE STREAM FOR FLOATING TO THE VALLEY. THE MOUNTAINS IN THE MIDDLE FOREGROUND HAVE BEEN DEFORESTED.

area, in sharp contrast to that on the denuded area, where erosion was heavy and during two storms excessive silt and detritus so clogged the instruments that the records were lost on these two occasions, when runoff and erosion were greatest of all storms of the rainy season.

The gazetteers also give records of floods in this district. That of 1730 tells that in 1513 (eighth year of Cheng-te) floods carried away and inundated more than a thousand ch'ing (15,130 acres) of agricultural land. Several hundred ch'ing of fields are recorded as again flooded by the Ch'in River in 1591 (Wan-li nineteenth year). In 1651, 1652 and 1653 there were floods which ruined more than 687 ch'ing (10,394 acres) of agricultural land. The supplementary gazetteer of 1881 tells of the land of a whole village being deserted because of calamity after calamity from floods.

In 1877 flood damages were heavy, after which taxes on the land of this village were revoked in perpetuity. One piece of school land is recorded as buried with sand and two others as washed away by floods. The gazetteer of 1730 records the exemption from taxation in 1657 of 10,417 acres (688 ch'ing 48 mou) of land damaged or destroyed and then deserted. Remaining crop land was only 30,652 acres (2,025 ch'ing 91 mou). In 1729 and 1730 (seventh and eighth years of Yung-cheng) 461.6 acres (30 ch'ing 50.9 mou) of land were recorded as newly brought under cultivation.

Extensive remnants of early forests are left on Mien-shan or Mien Mountain partly in this district and partly in the districts of Chieh-hsiu and Ling-shih. One area of ancient forest is carefully preserved by eighteen villages, which together control the cutting of trees. A temple stands in this communal forest, which also contains 4,000 or more of a rare species of white-barked pine (*Pinus Bungeana*).[28]

This area shows most of the facts shown in other areas already studied. Partial protection of forests, in this case mainly by villages, sometimes acting in a group, has prevented excessive erosion; but where sloping lands were cleared and cultivated, they have been damaged or ruined by erosion and abandoned for agriculture. Restoration of forest cover on such areas is delayed by grazing of sheep and goats; and destructive floods occur in streams that drain denuded areas.

Farther to the southeast near the corner of the province, Kao-p'ing District

[28] *Cf.* H. Smith, "Preliminary Report on Botanical Investigation in South and Central Shansi," *China Journal*, 3: 505–507. 1925.

shows a record similar, but with forests more a thing of the past and with floods more prominent in its history. As one writer in the gazetteer of 1880 put it: "Formerly able men vied with one another in profit from irrigation, but now . . . silt daily collects in canals and the waters are reduced . . . crops are damaged by excessive water in floods. Water brings ruin instead of profit."

Such in brief is the record in gazetteers and in the land of how deforestation, cultivation and erosion with consequent flooding and silting, have taken place in the Province of Shansi. This record covers only a part of the long history of China, and belongs to the "dark period" according to some historians.

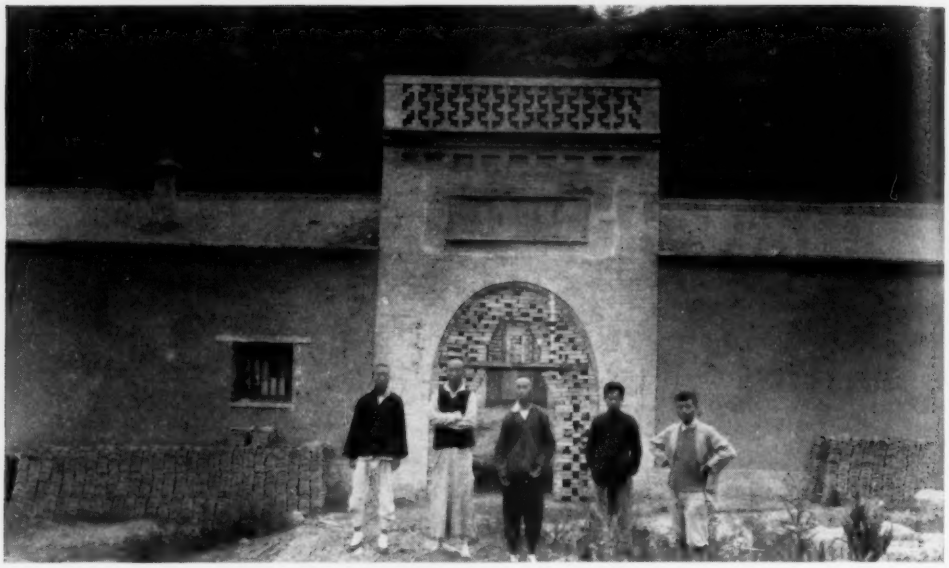
Conservation in Chinese History

The history of the treatment of forests in China before the Republic has been classified into three periods by Teng Shu-chun[29]: the Ancient Period, from earliest time to about 1100 B.C., the Golden Period from 1100 B.C. to 250 B.C., and the Dark Period from 250 B.C. to A.D. 1911. In the Golden Period rapid progress was made in steps toward conservation of land and forests. These measures suggest those now being applied in the United States. More than 2,000 years ago in China land was classified as to its best use, and regulations were set up for its distribution to and cultivation by the population. Commissions of mountain forests and of swamps were set up. Policing of foothill forests and of rivers and streams was provided for. The Commission for Mountain Forests was put in control of mountainous lands and the forests and set up rules and regulations for protecting and harvesting them. Cutting of timber was limited to certain periods of the year. And more surprising still, if one is surprised at the genius of the Chinese people, wild-life regulations were set up for the swamps and game and wild fowl. In short, we have in this remarkable era, when the classics of China were written by the sages, the principles of

[29] Teng Shu-chun, M. F. "The early History of Forestry in China," *Jour. For.*, 25: 564 *f.* Washington, 1927.

RAFTING TIMBER DOWN A STREAM IN THE FANG SHAN AREA

THE LOGS ARE MADE INTO GREAT SNAKE RAFTS WHICH ARE SKILFULLY GUIDED BY BOLD RIVERMEN DOWN THE SHALLOW WATER OF MOUNTAIN STREAMS TO THE VALLEY.



VIEW OF HEADQUARTERS OF A MATCH COMPANY

CONSTRUCTED TO HARVEST TIMBER OF A GREAT TEMPLE FOREST OF SOME TWENTY SQUARE MILES IN THE FANG SHAN MOUNTAINS. THE FOREST IS SPRUCE AND LARCH ON THE SLOPES, AND BIRCH AND POPLAR IN THE MOIST VALLEYS.

conservation set forth in remarkably clear outline, and apparently upheld for centuries with governmental regulations.

But these wise measures seem to have been relaxed with the decline of the Chow Dynasty and the growing strength of the feudal states when intense rivalry and conflict spread throughout the country. Warfare nullified regulations and fostered exploitation of forests and lands.[30]

Then followed what Teng has called the Dark Period of about 2,000 years. This period was ushered in by Ch'in Shih-Huang, whose great program of construction would have been possible only with abundant timber supplies, and is believed to have been the principal cause for deforesting extensive areas that were never allowed to grow up to forest again. Only in the temple groves and forests do we find remnants of the original forests of the Golden Period, to which the senior author has called attention. These remnant forests protected by temples are instructive in giving highly useful information, as samples of the original condition of soil and forests throughout most of China, as the sort of forest growth that the present climate will support, and as areas having the normal rate of geologic erosion when compared with erosion accelerated by clearing and cultivation of slopes, and finally as the goals of the new conservation program that may reasonably be achieved. In these respects "temple forests" have the highest scientific and practical interest in the reconstruction and conservation program of China. Our account of what has happened in the Province of Shansi is indicative of what went on throughout the greater part of China during the latter part of the Dark Period.

With overthrow of the reactionary Manchu Dynasty and establishment of

[30] Teng, S. C. *Id.*, p. 567. So also Chang, F. Y. "Historical Sketch of Chinese Forestry," *Jour. of the Agricultural Association of China*, No. 77, June, 1930, pp. 4 *f.* (in Chinese).

the Republic in 1912, there was begun a new period, which may be called the Period of Reconstruction. To its aid came modern pure and applied sciences of agriculture, forestry and engineering. In that year the Ministry of Agriculture and Forestry was established and forest nurseries were started throughout China. In 1914, this Ministry was combined with the Ministry of Industry and Commerce to form the Ministry of Agriculture and Commerce which has finally been changed to the Ministry of Agriculture and Forestry. Many Chinese students were sent to the United States, some of whom have been trained in fundamental and applied sciences of agriculture and forestry. But still more Chinese students were trained in these fields in American supported universities and colleges in China, and in national universities, and have become more and more influential in the Chinese Government. These well-trained men and women furnish the aims and major drive of the reconstruction movement in China.

Movements for Conservation in the Old and New Worlds

Poetic justice has worked its wondrous ways again in mutual aid by China and the United States in developing conservation in the two countries. So old and so new is the experience of these countries in use of their respective lands that such community of interest may at first seem to be remarkable. From China the United States, as we have seen, got much of its inspiration for conservation of forests; in turn China got from America a new impetus to principles of conservation that had been enunciated in China during the "Golden Period," more than twenty-two centuries ago. From America, China got her start in scientific forestry, although the senior author found in isolated parts of China, forestry practiced in greater detail than he had ever seen in Germany. It was under the late Colonel George P. Ahern, as director of the Bureau of Forestry of the Philippines in 1911 and later years that the movement for training Chinese students

SLOPES CLEARED FOR CULTIVATION AND LARGELY ABANDONED

IN THE CH'IN YUAN DISTRICT, SHANSI, WITH ONE SLOPE IN PROTECTED FOREST. SOIL EROSION IS HERE WAGING A WINNING FIGHT WITH CULTIVATION. THE BENCHING OF SOIL AGAINST HORIZONTAL STRIPS OF PERENNIAL GROWTH STILL PROVIDES SITES FOR CULTIVATED FIELDS.

RIDGE WITH VILLAGE FOREST ON THE FAR SIDE, CH'IN-YUAN DISTRICT
THE FIELD IS CULTIVATED TO THE VERY SUMMIT, BUT BECAUSE OF GULLIES WASHED IN THE SOIL COULD BE CULTIVATED CONTINUOUSLY NO LONGER THAN TEN YEARS.

at the Forest School in Manila began. Later a School of Forestry was established in the College of Agriculture and Forestry of the University of Nanking by Joseph Baillie, followed by Dean J. H. Reisner and then by Dean K. S. Kuo,* and other able Chinese leaders. Moreover, many Chinese leaders in forestry and conservation were trained in the United States, and became "American Returned Students." Of these, Ngan Han, trained at the Forestry School of Michigan, was the first director of forestry for China; and D. Y. Lin, a graduate of Massachusetts Agricultural College and later of the Yale Forest School, as professor of forestry at Nanking gave a series of lectures throughout China on conservation with special reference to forests, and created a national interest that has persisted and grown to this day but with setbacks due to internal and foreign wars, and has been a major influence in the Government for conservation and flood control. Many others too numerous to mention here have made important contributions to forest and soil conservation. Despite handicaps, remarkable progress in conservation has been made under the leadership of the Generalissimo Chiang Kai-shek in the national reconstruction program, the progress of which has amazed foreign observers, and carried on despite deep invasion of a ruthless foreign army.

The movement in the United States for the conservation of soils has grown out of soil surveys and experimental studies of soil erosion. About thirty years ago, Dr. H. H. Bennett, chief of the Soil Conservation Service, then a soil surveyor, challenged the method then in use of giving a new soil series name to a subsoil eroded bare of its top soil, of the same soil series.[31] This early work established a scientific basis for recognition of soil erosion in soil surveys. It was not, however, until experimental studies by Duley and Miller,[32] Bartel,[33] the senior author,[34] Bennett and Chapline,[35] Dick-

* Now director of the National Bureau of Research.

[31] Bennett, H. H. Soils of the United States. *U.S.D.A. Bul.* 96. 1913.

[32] Duley, F. L. and Miller, M. F. Erosion and Surface Runoff under Different Soil Conditions. *Mo. Agr. Expt. Sta. Research Bul.* 63. 1923.

[33] Bartel, F. O. First Progress Report on Soil Erosion Experiments. North Carolina Expt. Sta. Farm, Raleigh, U. S. Bureau of Public Roads, Div. Agr. Eng. 1925. Third Progress Report, 1928 (Mimeog.).

[34] Lowdermilk, W. C. Factors Influencing the Surface Runoff of Rain Waters. *Proc. 3d Pan-Pacific Science Congress*, Tokyo, 1926. Further

son,[36,37] Conner and Scoates,[37] Phillips,[38] and Bennett,[39] with numerous succeeding studies, made comparative measurements of the losses of rainfall by immediate runoff and of the losses of soil in this runoff that it was possible to compute how rapidly top soils were being washed away. These measurements indicated for the first time how soils deteriorate and are damaged through soil erosion far more rapidly than through cropping long before the spectacular gully stage sets in. Such experimental measurements disclosed how rapidly soil is impoverished and destroyed by erosion, especially on sloping lands under heavy rainstorms, when no measures of erosion control are used. Here, for the first time, was a factual basis for a study of the enormity of damage to land resources by soil erosion under unwise land use. These records of erosion wastage and loss aroused general interest in the problem of conservation on the part of business people, bankers, agriculturists and statesmen as well as of farmers who suffered first hand the losses from soil erosion.

Out of this better understanding of soil erosion and its menace to national welfare, there was launched the nation-wide movement for soil conservation in 1933 by means of demonstration projects located throughout badly eroding areas of the country by the Soil Erosion Ser-

Studies of Factors Affecting Surficial Runoff and Erosion. *Proc. Internat. Cong. of Forestry Expt. Stations*, Stockholm. 1929.

[35] Bennett, H. H. and Chapline, W. R. Soil Erosion a National Menace. *U.S.D.A.* Circular No. 33. 1928.

[36] Dickson, R. E. Results and Significance of the Spur (Texas)) Runoff and Erosion Experiments. *Jour. Am. Soc. Agron.*, 21: 415–422. 1929.

[37] Conner, A. B., R. E. Dickson and D. Scoates. Factors Influencing Run-off and Soil Erosion. *Bull. No. 411.* Texas Agr. Exp. Station. College Station, Texas. 1930.

[38] Phillips, Samuel W. Soil Erosion Work of the Bureau of Chemistry and Soils at Guthrie, Oklahoma. 2d Southwest Soil and Water Conservation Conference, 1931, 40–45. Ramser, R. E. Results of Experiments on Erosion Control on Guthrie Soil Erosion Experimental Farm. *Id.*, 46–53.

[39] Bennett, H. H. Dynamic Action of Rains in Relation to Erosion in the Humid Region. *Trans. Am. Geophysical Union*, 15th Ann. Meeting, 1934: 474–488.

FORESTED AND DENUDED SLOPES IN CH'IN-YUAN DISTRICT, SHANSI

AT THE RIGHT IS NATURAL FOREST PROTECTED BY THE VILLAGE OF TS'UNG-TZU YÜ. THIS FOREST AND THE SLOPE AT THE LEFT OF THE PICTURE WERE USED BY THE SENIOR AUTHOR FOR RUNOFF PLOT STUDIES OF COMPARATIVE RUNOFF.

vice as an emergency organization. The practical and far-reaching significance of this work gave rise to the passage of the Soil Conservation Act of 1935, passed without a dissenting vote in the House of Representatives and the Senate, that set up the Soil Conservation Service in the Department of Agriculture. This act marks the beginning of a new era in the relation of the American people to their land resources. For the preamble of this act states the purpose of the law in these words:

> Be it enacted by the Senate and House of Representatives of the United States of America in Congress Assembled, That it is hereby recognized that the wastage of soil and moisture resources on farm, grazing, and forest lands of the Nation, resulting from soil erosion, is a menace to the national welfare and that it is hereby declared to be the policy of Congress to provide permanently for the control and prevention of soil erosion and thereby to preserve natural resources, control floods, prevent impairment of reservoirs, and maintain the navigability of rivers and harbors, protect public health, public lands and relieve unemployment, and the Secretary of Agriculture, from now on, shall coordinate and direct all activities with relation to soil erosion. . . .

Modern methods of soil conservation in use in the United States by the Soil Conservation Service are developed out of an evaluation of past experience and current research. But in China, past experience has taught the Chinese farmer through centuries of hit-or-miss trial and error a few fundamentals in land use. The Chinese have found that lands must be nearly level if they are to be saved for use from generation to generation. Either they must be naturally so as in alluvial and delta plains, or they must be made so by terracing. The bench terrace, which reduces gradients of natural slopes for cultivation, has been successful where applied and maintained. A low gradient necessary in conserving soil also conserves rain waters in the soil for crop growth. Moreover, cooperation in concerted effort under a unified direction is also necessary to success in efforts for the conservation of soil and water. In China's long past, when such direction was lacking, conservation failed and lands wasted away. A single farmer is often helpless in the face of soil erosion

INTERIOR OF VILLAGE FOREST AT TS'UNG-TZU YÜ, CH'IN-YUAN DISTRICT
SHOWING A RATHER THIN STAND OF PINE AND A DENSE NATIVE SHRUB COVER. THE LATTER WAS THE MOST EFFECTIVE AGENT IN PREVENTING EROSION AND IN MAKING CONDITIONS THAT RETAIN WATER.

or of a flood, without the cooperation of others on the slopes above. This the Chinese had discovered, but had not been able to do much about it. With a background of geology and hydrology and soil science, conservation of soil and water in the United States comes to be recognized as a physiographic problem, and is best handled on a basis of drainage areas.

Out of such findings of the past and research of the present has come a national movement for conserving land, with its moisture and included plant foods. The program of this movement prescribes as a general principle contour farming supported by all necessary measures to increase the intake of rain waters by the soil under cultivation and grazing, to control unabsorbed storm runoff and lead it harmlessly down to natural drainage channels, and to reclaim badly eroding and eroded areas with mantles of vegetation. Supporting measures include contour strip cropping, broad base terraces, vegetal covers fully maintained, the use of crop litter or stubble mulch on soil surfaces, acting in the same way as forest litter to increase infiltration of rain and reduce erosion, the improvement of soil structure to increase its capacity to take in rain waters, supported by appropriate soil amendments, grassed waterways to lead unabsorbed waters to natural drainage channels, and gully control. Thirty-one and a half million acres of land in the United States have already been treated under cooperative farm plans worked out by field personnel of the Soil Conservation Service. More than ten times this area of good land is eroding and is urgently in need of treatment. The chief hazard to the land, both in China and America, is the neglect of known methods and lack of making adjustments in the use of land by appropriate experimental studies as rapidly as pressure of population impinges upon crop-growing capacity of the land. Demands upon land vary with passage of time and economic circumstance. Unless measures for conserving soils under such

GENERAL VIEW OF DENUDED SLOPE, CH'IN-YUAN DISTRICT, SHANSI

HOMOLOGOUS IN GRADIENT, ASPECT, ELEVATION AND SUBSOIL WITH FOREST PLOT 500 FEET AWAY. WHEREVER POSSIBLE THE SLOPE IS STILL CULTIVATED. ONCE THE ENTIRE SLOPE WAS CULTIVATED.

changes are varied to meet new hazards to the physical integrity of the resource, much of the national heritage of the land is irreparably damaged or destroyed before revised measures of improved land use can be found out by study or tardy experience. Trends in land use must be proved and studied with foresight to have ways and means already worked out to meet current needs for necessary crops with conservation of the national heritage in the soil.

Summary

Our survey of twenty-seven counties and prefectures in the Province of Shansi of China is already summarized with some typical excerpts translated from the Chinese, lest the paper be too long. As a whole these accounts are striking records of an early appreciation of needs and urgency of conservation, sound principles of which were enunciated more than twenty-two centuries ago. In some isolated parts of China, the senior author found forestry practiced in greater detail than he ever saw in Germany. Such areas are obviously remnants of larger managed areas in former times. The terracing of slopes in some parts of China, particularly in regions of the great loessial soil mantle, also represents practical and complete conservation of soils. Nevertheless repeated efforts at conservation of forests and soils in the Province of Shansi broke down for one reason or another. Among the more important causes were interruptions of orderly government, and the exploitation of areas, chiefly under a foreign dynasty of nomadic origin, the Manchus.

Mountainous regions of Shansi that were originally covered with dense forests were cut clear of timber leaving the region a place of desolation. Because of this, representatives of the Emperor became concerned and secured an Imperial Edict against this wastage of forests and lands. Restriction of such exploitation restored a forest cover in Wu-t'ai Shan. Armand David has suggested that cultivation of high slopes in North China followed the introduction of crops from the New World, corn and potatoes, adapted to higher altitudes than those previously cultivated. Introduction of such crops, of which we noticed evidence for this region, would doubtless promote such cultivation. From about 1656 on, the cultivation line was pushed up slopes of this sacred mountain region to bring on a period of devastating erosion from which the region has never recovered. Devastating erosion in the mountains brought about torrential floods charged with debris of soil and rock that wrought great damage to farm lands of the alluvial plains by flooding and overwash of detritus.

The recent reconstruction movement, with the benefit of principles and experience from both China and America, promises great things for the land and people of China when the invader has been driven out and peace makes possible undivided attention to the great task of reconstruction. The American people have much to contribute and much to learn from the objects and achievements of reconstruction in China. For these two countries have a unique advantage in producing all their own food supply; they have a like need for safeguarding all resources toward maintaining this advantage. The dreams of wise men of old may in time be realized with science and cooperation in conservation in the Old and New Worlds.

CATTLE RANCHING IN THE TROPICAL RAINFOREST[1]

By Dr. RAYMOND E. CRIST

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THERE has probably been more highly imaginative writing about the tropical rainforest belt ("jungle" in the vernacular) than about any other climatic region in the world, with the possible exception of the polar regions. In the mind of the middle-latitude public the heavy rainforest is densely populated with fierce man-eating animals, venomous snakes, and noxious insects by the countless million, and many pens have been kept busy giving this public what it wants. Most of the best-sellers about the tropics deal with either the terrors or the romance of that region—or both. Of course, it is hot at low elevations in the tropics, as is to be expected, but it never gets as hot anywhere in the American tropics as it does in the Middle West every summer—in Chicago, Kansas City, St. Louis or Cincinnati, for example. A case of sunstroke in the tropics is as rare as frostbite.

In the tropical rainforest southwest of Lake Maracaibo, Venezuela, there are fairly distinct wet and dry seasons. November, December, and January and May, June, and July are considered the wet months, that is, when the sun is farthest south, and also during its northern sojourn. During these months it rains almost every afternoon. After the rain the sun comes out, and the sensible temperature is even higher than before the shower. There is often a light shower about 4 or 5 o'clock in the morning. There is apt to be a convectional shower in the afternoon any time of the year, even during the dry season. The relative humidity is always high.

Land in the State of Zulia, Venezuela, which includes most of the area tributary to Lake Maracaibo, can not be purchased outright in the usual manner. The state retains control of all subsurface products. One acquires only the surface rights, and the rights to what is produced on the surface. Surface rights are valid only upon continued use of the land; if it is not used for a period of five years, it is considered abandoned, and anyone who wants to can settle on it, provided of course that he works it. This arrangement is very similar to that of the Kamarakoto Indians of the Venezuelan Guayana region, who have no title to land and can not inherit or transmit it. As long as a member of the tribe works his *conuco* he is entitled to all its produce; when he ceases to do so it reverts to the community. Even an unoccupied house belongs to anyone who wishes to occupy it.[2]

It was in the region of tropical rainforest southwest of Lake Maracaibo that Mr. McRae, an American engineer with a little capital and all his time to invest, decided to buy a cattle ranch. He bought the surface rights for 800 acres of pasture land, buildings, and stock on the ranch for 40,000 Bolivares, paying 10,000 down and 5,000 a year. He already has 40,000 B. worth of stock on it. If the worst happened and someone showed up with an old but clear title to the property, an occurrence only too common in Venezuela, the present owner would simply sell all his stock, roll up

[1] The field work on which this article is based was made possible by grants from the John S. Guggenheim Memorial Foundation and the Graduate Research Board of the University of Illinois.

[2] Simpson, G. G., "Los Indios Kamarakotos," *Revista de Fomento*, Año III, Nos. 22–25, p. 544.

A CLEARING IN TROPICAL RAINFOREST

THE BRUSH IS BURNED AS SOON AS IT IS DRY ENOUGH AND CORN IS PLANTED IN THE ASHY SOIL AMONG THE UNBURNED LOGS. AFTER A CROP OR TWO OF CORN, GRASS IS PLANTED AND THE LOGS ROT AWAY. THE PIONEER'S HUT, WITH ITS PLANTAIN PATCH NEARBY, IS IN THE BACKGROUND.

his barbed wire, sell what he could of his house materials and still be ahead of the game financially.

When a man wishes to found a ranch —and this was the case with Mr. McRae—his first task is to find laborers, whom he usually recruits from the ranks of the shifting agriculturalists who have already cut little notches in the forest along the river or, in this case, along the narrow-gauge railroad. He pays them their food while they are clearing the land. Only a few giant trees are left to serve as shade later. Once cut, the great mass of vegetation is allowed to dry and is then set on fire. The land is planted in corn, and grass or plantains are planted between the hills at the same time. When the corn is harvested half of it goes to the man who has cleared the land. The plantains or grass are allowed to grow to maturity. Another crop or two of corn could be and occasionally is grown, but by the end of three years the potash left by the burning has been leached out, and corn doesn't thrive anymore. And the price of corn fluctuates greatly; this year (1941) it is worth less than half what it was worth a year ago. Since plantains are used locally much as potatoes are in the United States, there is always a good sale for them both in the nearby and in the Maracaibo market. They net Mr. McRae some 500 B. a month now from about 45 acres.

One of the difficult problems in the American tropics generally is that of getting sufficient labor. This problem has been aggravated in Venezuela by the fact that thousands of laborers have migrated to the oil fields where wages are high. And the labor law shows little leniency for the entrepreneur. The result has been to put a premium on contract labor. A certain individual agrees to have a given piece of work done within a specified time. If a worker gets hurt on the job it is the worry of the contractor, not of the rancher or the Mayordomo. The former can drop out of sight for a while or start working in another State—not so easy for the rancher. At present two men care for the cattle and hogs. On the average about five are engaged in other tasks, such as clearing new land, cleaning pas-

A WELL-DEVELOPED FIELD OF GRASS

THE LEVEL LINE IN THE MIDDLE GROUND IS FORMED BY THE TOPS OF PLANTAINS BEYOND WHICH SECOND GROWTH TREES CAN BE SEEN IN THE LEFT BACKGROUND. IN THE RIGHT BACKGROUND THERE IS VISIBLE A VIRGIN TROPICAL RAINFOREST.

ture, stretching barbed wire, gathering plantains. They are given 2½ B. a day with food, or four if they board themselves. Warm weather adversely affects the appetite of some people, but not necessarily of men doing hard work even in the heat of the tropics. One man was found who ate four pounds of cheese a day, besides two plates of rolled oats for breakfast, and three roast plantains at each sitting. Fortunately he ate many oranges between meals. It was too expensive an experiment to see how long this could last, and he was discharged at the end of the month.

At the ranch house itself, separated as it is from the virgin forest by wide stretches of cleared land, mosquitoes are rare. The house is not hermetically screened as yet but will be soon. But mosquitoes are very bad in or near the forest where the *conucos*, or kitchen gardens, or homes of the workers are located. Malaria is all too common, as well as diseases and parasites of the intestinal tract—hook worm, amoebic dysentery, etc. No statistics are available, but infant mortality rates are certainly high. The usual diet of the workmen consists of plantains and white cheese. Those who can afford it have a somewhat more varied diet. The Mayordomo, for instance, adds beans, dried fish, meat and noodles to his diet. Fortunately, good water is obtainable at relatively shallow depths (the ranch gets good water at a depth of eight meters) but in many cases wells are too shallow, improper care is taken of sewage, and water gets polluted. A big step forward in this area, as well as in the entire country, would be a campaign for a wide diffusion of the rudiments of sanitation. Even the most primitive conveniences are not available. Slops are thrown out near the house. Plumbing is of the banana patch variety.

Mr. McRae has some 800 acres of pastureland, over 500 of which are improved. He hasn't enough cattle at present to warrant getting the other in shape. He had just sold 40 fat steers, and now has 260 head of horned cattle left. One hundred more will be ready to sell within a year. There are 40 cows that will calve within three months and

SLEEK STEERS FATTENING IN THE LUSH PASTURES
WHERE FORMERLY GREW A DENSE STAND OF RAINFOREST.

30 heifers to calve within the next year. There are 50 cows giving milk now, and 46 calves. Cream is the profitable source of income. White cheese is made of the skimmed milk. He now makes about 400 B. a month from the dairy business, but hopes, with more cows, to make about 1,300 B. a month. Hogs are a kind of by-product of the dairy business—twelve old razor back sows are now being fattened for market and only the better looking ones are being kept. They are fed the whey. The man yells "chun chun chun," and they come running from every direction. They are also fed cooked Guinea bananas which fatten them rapidly. At present they still forage too much. Even so they are not lean

A PASTURE FIELD WHICH HAS BEEN CLEARED OF SMALL TREES
THEN ALLOWED TO REST SIX WEEKS. THE HEIGHT OF THE GRASS MAY BE JUDGED BY THE FACT THAT ONLY THE HEAD OF THE MULE WHICH MR. MCRAE IS RIDING CAN BE SEEN.

and muscular, but rather fat. When rendered the fat is more like white oil than corn lard, but perhaps it would look different in a refrigerator. The big risk in the hog business is the danger of cholera. Vaccination is necessary every three months if one wants to be sure of not losing them. At present Mr. McRae has about a hundred sows, shoats, and pigs. Only the better looking sows are being kept for breeding purposes, and the herd is being improved by what looked like a Duroc boar.

All the maintenance work in the ranch is taken care of by the Mayordomo, a native Venezuelan, who thus far has proved trustworthy. The cost of upkeep is shared, as is the income from the farm. The only expenses which are borne by the rancher alone are those of expansion. Some steers had just got over the fence into a neighbor's plantain patch. The neighbor wanted 120 B. damage; the judge settled it at one fourth that amount. This was the first time such a case had arisen, and the fine was paid by the owner on condition that from then on such costs would be shared. It is part of the Mayordomo's job to see after fences.

About every three or four months a pasture gets full of weeds and small trees which are cut out at the cost of about a dollar an acre, and the field is left to rest for about six weeks. At the end of that time the fresh pasture of very fattening Guinea grass is higher than the backs of the steers when they are turned in. Quite frequently both grass and weeds are cropped close, corn is planted and acts as a cleaning crop. After it is harvested—in five months—the grass, without reseeding, comes up thick and lush, and makes excellent pasture again. A grass called Paéz is used for milch cows. Ticks don't seem to live well in it. In the ordinary Guinea grass pasture there are many ticks—one gets pretty well covered with them walking through the grass. But there are so many that no attempt is made to kill them; one brushes them off with a leafy branch. If a pasture is left vacant for six months ticks die, apparently of starvation. An important source of income is that derived from pasturing lean steers from the Llanos at 4 B. apiece per month. They are bought in the Llanos for 60 to 80 B., driven across the mountains and fattened in these pastures for six months, after which they are worth at least twice what they originally cost.

A STREAM-LINED, AIR "CONDITIONED" DAIRY BARN IN THE TROPICS

One is amazed, as one travels along the railroad for the first time and suddenly sees the dense tropical rainforest on both

MILKING TIME IN THE TROPICS

THE PRESENCE OF THE CALF, TIED TO HIS MOTHER'S FRONT LEG, AIDS THE COW IN THE PROCESS OF "LETTING DOWN" THE MILK, SO THE MILKER ASSURES US.

sides of the track give way to tall green and luxuriant pasture, as pretty as a field of well-developed winter wheat in May. And in these fields browse cattle hardly visible because of the high grass. They are short haired and as sleek as cornfed Herefords in Illinois or as the milch cows in the rolling pasturelands of England or Brittany.

Thus it is not only possible to cut down tropical rainforest and keep it at bay by planting grass, but it is possible

TWO HORSE LOADS OF PLANTAINS READY FOR SHIPMENT TO MARACAIBO

VIA THE NARROW GAUGE RAILROAD TO ENCONTRADOS, THENCE VIA THE ENCONTRADOS RIVER AND LAKE MARACAIBO TO MARACAIBO.

to do this privately, without government subvention and, at the same time, very profitable. Of all the business ventures I have seen in recent years this seems to have least chances of being a failure. The government might confiscate all large holdings or there might be a shortage of workers, but such eventualities are possible anywhere.

Of course this kind of business can not be hand-to-mouth or self-sufficient. There must be an assured market and transportation facilities to that market. Maracaibo is the market, and the railroad, the Escalante River and Lake Maracaibo, is the means of transportation. The railroad is a good example of what artificial transportation routes mean in the development of a country, even if that country be tropical rainforest. Furthermore, it makes it possible for the ranchers to live in the healthful mountain area, preferably in or around Mérida, and visit their ranches only when necessary. Even before the railroad was built ranches were strong along the various rivers flowing into Lake Maracaibo, as they still are. In this region the soil is exceptional too—rich alluvial and not the usual leached residual, which is indeed difficult to grow crops on. On Mr. McRea's ranch the soil is well drained, yet moisture retaining, so that even in a drought it is not too dry. Yet this same rich alluvial soil must follow all along the eastern side of the great Andean back bone of Central and South America, and the tropical rainforest areas could be cut away and the regions thus complement the densely populated mountain communities of Peru and Ecuador, for example, if only highways and railroads were built, or even good trails over which cattle could be driven to market. The road from Bogotá to VillaVicencio in Colombia, tapping the rich resources of the tropical lowlands, has already proved its value.[3]

The contrast is indeed very great between this intensive cattle ranching where the original natural landscape has been wholly substituted by a man-made one, and the extensive type in the Llanos, where the natural landscape is exploited as found, without any change at all.

In this area the most important factor in making profitable exploitation of the tropical rainforest possible is transportation facilities which tie the area to a market: the railroad, rivers and Lake Maracaibo. Access to an expanding market has spelled growth and development for many an area which would otherwise have only half heartedly supported a miserable population.

AN EX-MONARCH OF THE FOREST
ORIGINALLY LEFT STANDING FOR SHADE. NOW, WITH MOST OF ITS BRANCHES BLOWN OFF, IT IS A PREY TO CREEPING VINES, AND PARASITIC AND EPIPHYTIC PLANTS

[3] R. E. Crist, "A Cultural Traverse Across the Eastern and Central Cordilleras of Colombia," *Bull. of Pan American Union*, 1942: 132–144.

THE EXPANDING USEFULNESS OF A PORTION OF THE SPECTRUM

By JAMES M. KETCH

ILLUMINATING ENGINEER, GENERAL ELECTRIC COMPANY

In 1672, Sir Isaac Newton announced to the scientific world his conclusions from some experiments which he had been conducting at Cambridge on the decomposition of white light by a prism. In his experiment he admitted the light of the sun into a darkened room through a hole in a shutter. Without the prism, he saw the image of the sun on the opposite wall of the room; when the prism was placed close to the hole, the sun's image spread out in one direction making a new pattern made up of the colors of the rainbow. Later, by means of a convex lens he caused the colors to converge again into the original white light. In this way Newton discovered the solar spectrum.

During the years that followed, Newton's spectrum—now known as the visible spectrum—grew enormously at both ends. By research, it has been extended beyond Newton's spectrum through the shorter wave lengths of ultra-violet, x-rays and gamma rays, to the shortest cosmic rays, and beyond the longer visible wave lengths to include infra-red, radio, and the longest electric waves of electric generators.

If we were to discuss intelligently the complete known spectrum it would be necessary to include the work of the medical profession, the x-ray specialist, the radio engineer, and the electrical transmission engineer, as well as that of the illuminating engineer. Our discussion will include only applications of energy sources from the visible region and those on either side: the ultra-violet and the infra-red.

We are under the stress of war with its urgent call for more and more industrial production and it is fitting, therefore, that we stress the expanding usefulness of our spectrum because of the increasing benefits to industry in the applications of the new light and radiant energy sources during the present emergency.

The Visible Spectrum

The white light, of the visible spectrum, has served mankind throughout the ages. Typical sources, which in addition to visible light also produce infra-red and ultra-violet, include the sun, natural daylight, arc lamps, and incandescent filament sources. The break up of the light from those sources into the component colors of its spectrum has, until the past few years, been of academic and secondary interest to the majority of illuminating engineers. To them, the spectrum was an interesting bit of science studied in the college physics laboratory and written up in experiments which started with "Purpose of the Experiment" and ending with "Conclusions."

They were interested, naturally, in the individual colors for decorative purposes, but applications were limited because of the inefficient methods of obtaining such colors. To obtain some colors —blue or green, for example—from incandescent lamps it was necessary to absorb, and waste, 80–95 per cent. of the generated white light, and even to obtain a near-daylight quality, one third of the light was absorbed by a blue filter glass bulb.

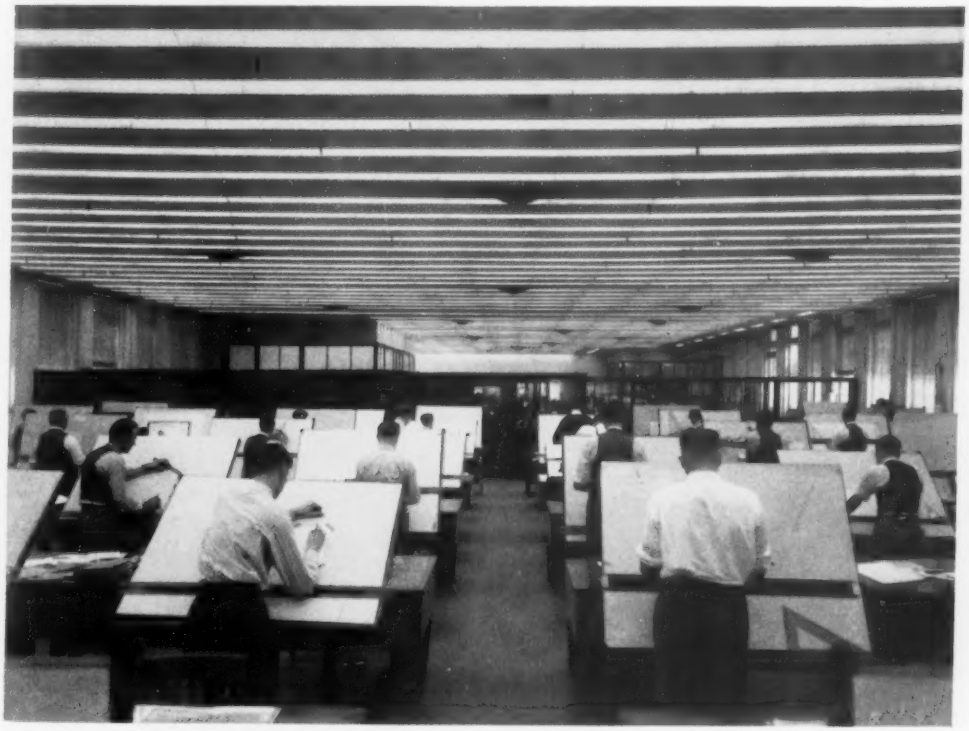
Of more importance to the lighting engineer than color, a decade ago, was the control of white light by means of reflecting, refracting and diffusing media

into candlepower distribution patterns that were most useful.

Beginning with World War I and increasing rapidly during the years that followed, the broader interest of the lighting profession was in footcandles and glare. These two came to be called popularly "positive" and "negative" light because the higher the footcandle value—positive light—on objects to be seen the greater was their visibility, but with more and more glare—negative light—less and less could be seen.

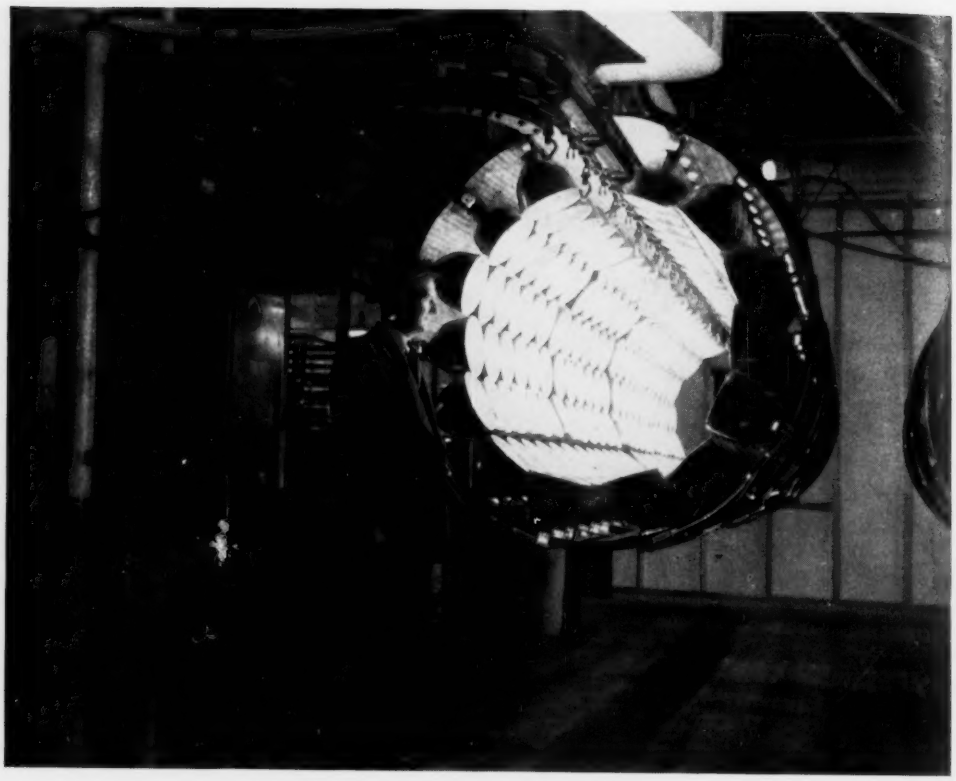
Researches under way following the war were based on a new concept that the human being is a complex seeing machine. As these researches on seeing became better understood there evolved a basis for the application of footcandles and reduction of glare called the Science of Seeing. This new science indicates that, for optimum seeing, the human being requires hundreds of footcandles rather than the ten, or less, then in common use for industrial purposes. It has been but recently, however, that the light sources, equipments, and application methods have been developed for obtaining those higher lighting levels comfortably.

Fortunately, the present emergency finds us with efficient and versatile new light sources, controlling equipments, and methods of applying them, that make the higher levels of 50, 100 and even 500 footcandles both practicable and economical. There has been a convergence also of several wide-spread researches under the sponsorship of the Industrial Lighting Committee of the Illuminating Engineering Society. These researches have contributed much



TYPICAL MODERN INDUSTRIAL DRAFTING ROOM

WITH CONTINUOUS ROWS OF FLUORESCENT TROFFERS THREE FEET APART. THE MAINTAINED ILLUMINATION IS ON THE ORDER OF SEVENTY-FIVE FOOTCANDLES.



TYPICAL BANK OF INFRA-RED DRYING LAMPS

MOUNTED ON A CONVEYOR LINE WHICH CARRIES PAINTED PARTS THROUGH THIS TUNNEL. DRYING IS ACCOMPLISHED DURING THE SHORT TRAVEL. INFRA-RED HEATING DEVICES TAKE MANY OTHER FORMS TO SUIT THE INDUSTRIAL PROCESS.

on methods of applying light to many of the difficult and diverse visual tasks of industry.

Daylight quality and colors in some of the newer light sources are produced directly, and at high efficiencies, rather than by the absorption methods of five years ago. Because of the lower brightness of the fluorescent lamps, less shielding of the sources from direct view is necessary than that required for the higher brightness incandescent sources.

The fluorescent lamp is tubular in shape and requires entirely new types of reflecting equipments and methods of application. The efficiencies of some of the mercury and fluorescent light sources compared with those of standard incandescent lamps are shown in the following table.

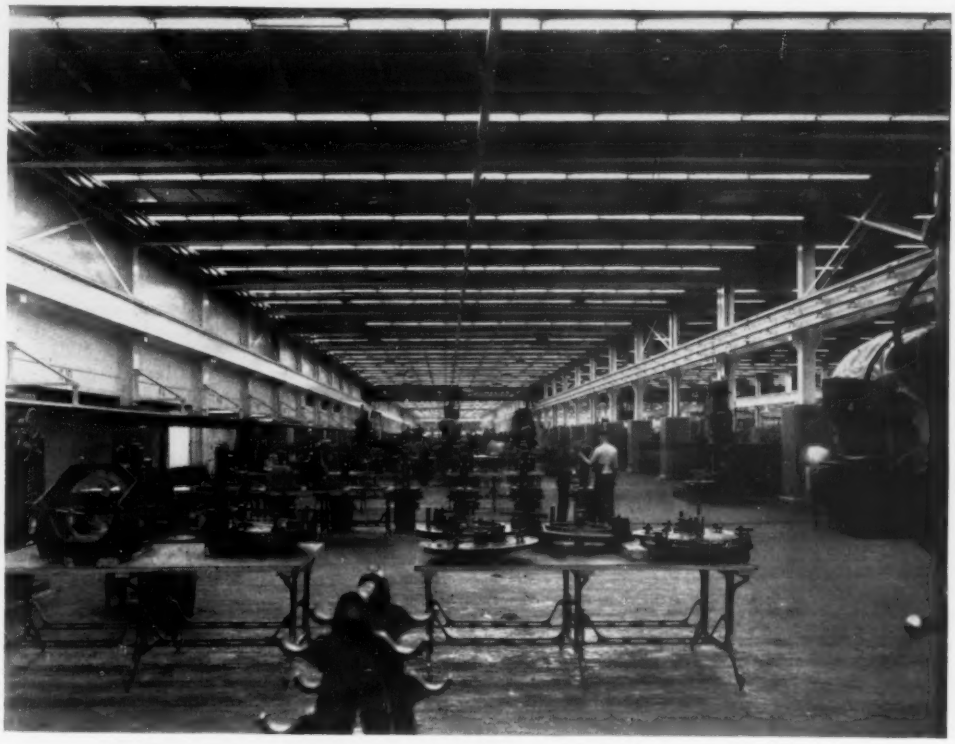
Lamp	Lumens per watt	Rated av. life hrs.
Incandescent, 1000 watt	21	1000
Mercury vapor, H-1, 400 watt	40	3000
Mercury vapor, H-5, 250 watt	40	2000
Mercury vapor, H-9, 3000 watt	40	2000
Fluorescent (3500°) 40 watt	52	2500
Fluorescent (3500°) 100 watt	42	3000
Fluorescent (daylight) 40 watt	42	2500
Fluorescent (daylight) 100 watt	37	3000
Rectified fluorescent, 85 watt	47	3000

The spectra of two of these lamps—the 400 and 250 watt mercury vapor—are discontinuous, or banded, and therefore have the general color characteristics of the older Cooper-Hewitt lamps: not suited where color discrimination is important, but applicable for general industrial lighting purposes.

As we review some of the applications of these lamps to a wartime industry two factors stand out as important: (1) The high footcandle levels (30 to 500) required for optimum seeing are practicable and generally accepted; (2) there is a definite trend toward lines of light of relatively low brightness which can be conveniently applied to lines of machines, benches, and conveyor lines.

Lines of light, areas of light and higher illumination values have found their way likewise into drafting rooms, offices, and stores. In offices they are conveniently combined with acoustical ceiling materials.

As was stated earlier, in order to obtain colors from the incandescent lamp it is necessary to absorb all unwanted rays of the visible spectrum, and consequently the production of most colors from incandescent lamps is extremely inefficient. The production of colored light by fluorescent lamps, is, however, very efficient—green being nearly two hundred times as efficiently produced as by incandescent sources. The production of daylight spectral quality reduces to the simple problem of mixing the phosphors of several colors in proper balance as contrasted with the subtractive filter method employed in daylight incan-



CONTINUOUS ROWS OF FLUORESCENT LAMPS

USUALLY EMPLOYING TWO 40- OR TWO 100-WATT LAMPS IN EACH ROW. THIS TYPE OF LAMP HAS BECOME FAIRLY STANDARD IN THE MODERN FACTORY.

descent lamps. These possibilities of producing color at high efficiencies give the lighting engineer new dimensions of color and colored light applications.

A recent investigation by a lighting engineer and an industrialist on "Improved Vision in Machine Tool Operations by Color Contrast" shows some very interesting possibilities for increased war time production, and indicate a renewed interest by lighting engineers and users in the logical coordination of light and paint to achieve pleasant surroundings and increased ease and comfort in seeing.

Another light source not listed above is the 1000 watt, H-6 mercury lamp which is about the size of a cigarette. It has a rated life of seventy-five hours and has an efficiency of sixty-five lumens per watt. Its application is now devoted chiefly to the photochemical processes—engraving, television, also searchlights. It is a source rich in ultra-violet radiation and is finding applications for other chemical and photo-chemical conversion processes that require large quantities of ultra-violet radiation. This lamp requires cooling either with forced air or by means of a water jacket around it and some means of circulating about 3 quarts of water per minute to keep operating temperatures of the quartz tube within safe limits.

All fluorescent and mercury arc sources require ballasts to control their arcs. The wattage consumed in such ballasts must, of course, be added to the lamp wattages when figuring ultimate over-all efficiencies.

Infra-red Region

Beyond the red end of the visible spectrum is the longer wavelength infra-red

USE OF FLUORESCENT LAMPS IN AN OFFICE ROOM

VIEW OF LIGHTING IN A LARGE AIRPLANE ASSEMBLY PLANT
EACH INDIVIDUAL REFLECTOR CONTAINS TWO 85-WATT TYPE RF FLUORESCENT LAMPS.

region which manifests itself as radiant heat. Since incandescent lamps normally radiate eight to twelve per cent. of input energy as visible light and from sixty to eighty per cent. as infra-red radiation, it is natural that they should find applications for radiant heating purposes.

For some applications requiring invisible infra-red only, lacquer and glass filters are available which are opaque to visible radiation but which transmit most of the infra-red. New photoflash lamps operating on this principle have but recently been made available. These lamps which produce very little visible radiation, used in conjunction with standard infra-red films, can serve news photographers under forced blackout conditions if necessary.

Each war brings with it accounts of secret and invisible rays capable of doing incredible damage to enemy fleets and airplanes. We quote from R. A. Houston's interesting text "Light and Color."

> The possibilities of invisible rays have always appealed to the imagination of inventors and cranks, and, as any one connected with the government departments dealing with inventions knows, there were many mad schemes proposed for using them during the war. The infra-red rays or heat rays have been on the whole the more popular. They have a quite respectable antiquity. Archimedes, the most celebrated mathematician of ancient times, is said to have set the Roman fleet on fire, and destroyed it at the siege of Syracuse in 212 B.C. by concentrating the heat rays of the sun upon it with concave mirrors. The fleet was then one bow shot distant from the walls. (But the story is either a pure invention or arose from a misunderstanding.)
>
> Napier of Merchiston (1550–1617), who discovered logarithms, also proposed to destroy an enemy's ships by heat rays, as part of a general scheme "for defense of this Iland" and the rendering of Britain safe from all her enemies.
>
> And H. G. Wells in the "War of the Worlds" has let his imagination play upon heat rays in

INSTALLATION OF FLUORESCENT LIGHTING BY CEILING TROFFERS
SUPPLEMENTED BY SEVERAL GERMICIDAL UNITS MOUNTED ABOVE THE BLACKBOARD TO IRRADIATE THE AIR AS IT CIRCULATES IN THE UPPER PART OF THE ROOM.

an unfettered manner, and easily outdistances both Napier and Archimedes. The heat ray was the Martian's chief weapon of war. It was a noiseless and blinding flash of light which carried miles. Pine trees burst into flames, as the shaft of heat passed over them, and every dry furze bush became with one dull thud a mass of flames. It blotted out all living things, and in its track the dark ground smoked and crackled.

Important to our wartime industry has been the development of a line of heat-generating incandescent lamps called drying lamps. These lamps operate at a low luminous efficiency which makes them of little value as light sources but their use is being rapidly expanded for many industrial processes requiring heat for the curing or polymerization of paints or lacquers, for the evaporation of moisture, and for mass heating of materials.

The speeding up of production implies a reduction of the time for manufacture and processing of materials and a conservation of productive space. For many industrial heating problems both time and space can be conserved by drying-lamp applications. The advantages of this type of heating are apparent because by this method (1) greater concentrations of energy possible on the work speed up the drying time (savings as high as 90 per cent. of the time are possible), (2) smaller and less expensive ovens are practicable, (3) ovens can often be placed above the floor thus releasing productive space for machine tools, (4) graded temperatures can be obtained on a constant speed conveyor by the spacing or wattage of the lamps used, (5) there is no heat-up or cool-off time necessary, and (6) the interiors of

factory spaces can be made more comfortable for the workmen since it is not necessary to heat the factory interior as is usually the case when heated air methods are used.

Ultra-violet Region

Yesterday, a scientific fact; today, a production tool. The mercury arc, used as a basis for many of the new light and radiant energy sources, has a number of characteristic lines and bands both in the ultra-violet and visible sections of the spectrum. By a control of the pressure within the tube housing the arc the amount of energy in those lines or mercury bands is under some control. For example, the pressure in fluorescent lamps is very low which makes it possible to convert a half of the electrical energy into ultra-violet energy at one of the principal mercury lines, 2537A. By using the proper phosphors—fluorescent and phosphorescent materials—much of the energy of this invisible 2537A radiation is converted by fluorescence to the visible region. Not only are colors obtained directly by using the proper phosphors but, by mixing the right phosphors, white light is obtained at much higher efficiencies than those of incandescent lamps. This method of producing light makes low-temperature, low-brightness sources practicable.

For the purposes of this discussion we are interested in three principal parts of the ultra-violet region. One centers around 2650A and has a germicidal, germ-killing, action. The second centers at 2967A, which is the peak point of the erythemal effectiveness. The third centers around 3650A at which point we find photographic and fluorescent effects.

AN APPLICATION OF BLACK LIGHT—NEAR ULTRA-VIOLET
TO IRRADIATE THE CEILING DESIGN PAINTED IN LUMINESCENT PAINT.

The first practical venture into the ultra-violet region was made several years ago with the development of the S–1 and S–2 sunlamps. These lamps duplicate sunlight in a practical way. The source of radiation is a combination incandescent filament and short mercury arc. By means of a special glass bulb the short waves, which are shorter than those reaching us from the sun, are absorbed. These lamps found use by the medical profession as sources producing Vitamin D, substituting for codliver oil, and in the treatment of rickets. Their use in homes in the winter months gives the beneficial effects equivalent to a summer sunshine.

More recently another section of the ultra-violet region has claimed our attention. The bactericidal effect of ultra-violet radiation has long been known. The recent development of efficient sources of this germicidal radiation makes possible its practical use in many hygienic and industrial problems involving organisms ranging from mold spore to pathogenic germs and viruses.

The lethal action of ultra-violet is characteristic only of those wavelengths which penetrate, and are absorbed by, the bacterial organisms. For practical purposes this spectral range is from 3000A to 2000A, with a maximum at about 2650A.

It is a remarkable coincidence that one of the principal mercury lines, the 2537A resonance radiation line of the mercury arc, is very close to the 2650A line of maximum bactericidal effectiveness. This is the same line used in the fluorescent lamps to produce a visible fluorescent effect from the phosphors inside the glass tubes. By enveloping the mercury arc in a special glass tube which has some of the characteristics of fused quartz, it is possible to transmit appreciable amounts of bacteria-killing radiation.

By far the most important application of these sources of ultra-violet light has been in the germicidal treatment of air to kill air-borne bacteria. Many of our diseases are transmitted by air-borne bacteria which are relatively inaccessible and can not be killed by ordinary germicidal agents without creating objectionable effects in the air itself. Heat may serve as a germicidal, but there remains the problem of its removal. Air washing and filters are effective, but are more limited to forced air systems.

A simple solution is to employ germicidal lamps in interiors with the lamps shielded from view. The natural convection and circulation of the air carries the bacteria past the sources where they are killed. One 30 watt germicidal lamp irradiating the upper half of a 4000 cubic foot room produces the equivalent sanitary ventilation of 100 changes of air per hour. Such actual changes of air per hour by means of outdoor openings and windows would be impracticable during most seasons, and perhaps bothersome at all times.

These new germicidal lamps have applications in hospital operating rooms and where barriers are created at doorways between cubicles. They have many possibilities of use in schools, stores, theatres, recreation rooms and military barracks where numbers of people congregate.

Other applications have been made in the air ducts of ventilating systems, and for direct application in the sanitary storage of drinking classes, dentists' instruments, etc. They have been applied to the sterilization of milk bottle caps, sanitary packaging and processing, and in the sterilization of hotel bathrooms.

The third section of the ultra-violet region of interest to us is that nearest the visible spectrum. It is the one popularly known as "black light." It happens that one of the principal mercury

arc spectrum lines is at 3654A. The excitation range of many materials that fluoresce is a fairly broad one that peaks at about this same wavelength. Since all of the mercury arc sources also produce visible light, it is necessary for some applications to use filters over them which efficiently transmit the ultra-violet and absorb most of the visible. There are also phosphors which, when used in the fluorescent lamps, produce this same general effect by converting the energy of the 2537A-line to a longer ultra-violet, plus some visible light.

Of course the dramatic and decorative effects of black light sources used in connection with fluorescing and phosphorescing materials are well known. Of most importance to us now they find their use industrially for the inspection of many organic and inorganic substances. It is very possible also that those materials which phosphoresce will find usefulness during blackout conditions to mark machines, gun turret instructions, tunnel and shelter entrances, pathways, roads, exits, etc.

May we conclude, then, with the thought that Newton's visible spectrum has increased in its importance not only in the new attitude regarding seeing, production, safety and defense, but our interest has expanded and found added usefulness in the invisible infra-red, and in three sections of the ultra-violet. We can, today, pick the points on the ultra-violet, visible, and infra-red regions that we want to use, and find practical, workable, light or radiant energy sources to produce those wavelengths.

VALUES NOT EASILY REGAINED

In this Review, three years ago, under the heading "Night over Europe," an attempt was made to describe the disaster which the war was bringing to universities and laboratories both in England and on the Continent. The processes of disintegration had already begun. Institutions dedicated to the extension of knowledge were being geared into the war machine. The necessities of military mobilization had decimated faculties and student bodies alike. Cultural values upon which civilization is based were being thrown to the winds as the intellectual blackout spread across half the world.

Today the long shadows of the blackout are lengthening inexorably over the United States. We are fighting for a future in which free institutions can live, but to achieve that end we are sacrificing values which, once they are lost, are not easily regained. The crisis presents us with a problem of delicate balance: how to win the war and at the same time preserve those intellectual ideals and standards, those "great things of the human spirit," without which a military victory would in the end be nothing but ashes. History shows us that it is possible to lose a civilization even while armies and navies are triumphant.

As in Europe, so here at home, liberal education has been discarded for the duration. Our universities are now instrumentalities of total war. Technology is left as the one subject which must be taught. History, economics, literature, philosophy—the whole range of the social sciences and the humanistic studies—have been crowded out of the picture by the pressure of higher priorities. Our young men are not to be trained in liberal understanding; they must be made into soldiers. Of necessity, their education must be an education in violence. Their participation in the cultural and social heritage of civilization is adjourned. For the time being, at least, their generation may not share in the humane tradition on which alone the building of a worth-while future depends.—*Raymond B. Fosdick in the Rockefeller Foundation Report for 1942.*

FLUCTUATIONS IN THE ABUNDANCE OF THE ALASKA HERRING

By EDWIN H. DAHLGREN and L. N. KOLLOEN

BIOLOGISTS, DIVISION OF FISHERY BIOLOGY, FISH AND WILDLIFE SERVICE, U. S. DEPARTMENT OF THE INTERIOR

SINCE man first began harvesting the wealth of the sea, he has found the herring to be among the most valuable resources placed at his disposal. Because their range includes nearly all the temperate waters of the northern hemisphere, they have been readily available to large masses of people. They are found in dense shoals, consequently are easily captured, which makes them a cheap source of tasty and nourishing food. Then, too, they have been found to be ideal for processing into meal and oil, the former to be used as a food for livestock, the latter for the host of purposes to which animal fat has been found adaptable. This processing has greatly enhanced their value in commerce of recent years. In addition to these direct uses, the herring are of tremendous hidden importance in that they provide food for a multitude of larger forms of fish and mammals which, in turn, are of economic value. Truly the herring hold a key position in the chain of nature by which the boundless quantities of microscopic life in the oceans are changed to a form usable by man.

Although the Pacific herring (*Clupea palassii*) is of less importance in the world economy than is the closely related Atlantic form (*C. harengus*), it supports an industry in Alaska alone which employs hundreds of men and contributes millions of dollars in new wealth to the nation each year. In this, as in other of our valuable natural resources, a conflict exists between the interests of exploitation on the one hand and those of conservation on the other. It is the contention of the former group that the supply of herring is virtually inexhaustible, and that the fluctuations in yield which are so evident in the fishery are due solely to the chance occurrence of conditions which determine whether or not the herring stocks will be available to the fishermen. This contention should be critically examined.

That great fluctuations occur in the herring fishery becomes evident from an examination of Fig. 1, which shows the production of the three areas which have been most extensively exploited during the past quarter century. Since no measure of the amount of fishing effort expended in making these catches is included, this chart can not be construed as indicating true abundance of the stocks. The Southeastern district, which was the first of these areas to be developed, has been devoted primarily to a reduction industry in which the fish are processed to recover the oil and meal. Until the decline in abundance, which occurred there in recent years, it was by far the greatest producing area in the Territory. The Prince William Sound and Kodiak districts were more recently developed, first as a source of the mild-cured product, more recently as reduction fisheries.

In each of these districts the fluctuations in catch which followed their initial period of expansion have been due in some measure to changing economic conditions which have governed the demand for the products and so governed the amount of fishing effort expended. Aside from this, however, the supply of

herring has been so erratic as to have resulted in much economic loss. The question arises as to the causes of these great fluctuations in the supply available. Were they only a reflection of changes in availability of the schools to the fishermen, or were they due to real fluctuations in the abundance of the stocks on which the fishery has depended?

Such fluctuations in the abundance of herring, with corresponding fluctuations in the catches made by the fishermen, may be attributed to one or more of the following factors:

Changes in the availability to the fishermen from year to year of the schools of herring at the usual fishing grounds. These changes may be quite independent of the true abundance yet result in great variations in the catch made by the fishing fleet.

A significant reduction in the abundance level of the species as a direct result of the removal from the stocks of the tremendous numbers of fish required to support an intensive fishery.

Natural fluctuations in abundance, the result of varying degrees of success attending spawning so that in some years a large number of recruits enter the adult stocks, in other years but few. This might occur largely independently of the changes in availability or of the withdrawals imposed by the fishery.

Changes in the migration routes of the herring with the abandonment of the usual feeding grounds in favor of other grounds unknown to the fishermen. Such changes would result in fluctuations quite independent of those caused by any of the above considerations.

It must be realized, before a true understanding of this problem is possible, that each of these fishing districts is supported by a body of fish resident therein and independent of each of the other areas. A rise or decline in abundance in any of these districts will not necessarily be reflected in similar fluctuations in the others, since each is dependent on separate bodies of fish. Furthermore, within each of these major districts there are known to be individual bodies of fish which do not mingle with adjacent groups, but which remain as

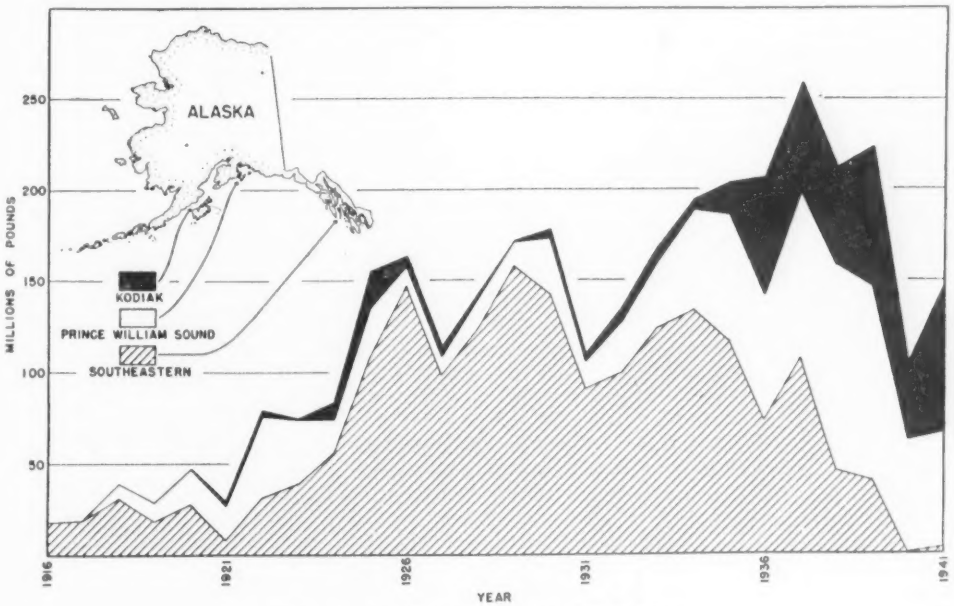


FIG. 1. PRODUCTION OF HERRING
IN THE THREE MAJOR PRODUCING AREAS OF ALASKA DURING THE PAST QUARTER CENTURY. THE INSERT SHOWS THE LOCALITIES OF THESE PRINCIPAL FISHERIES.

distinct stocks with feeding and spawning grounds separate from the others and with different migration patterns. The verity of these assertions has been established by the statistical analysis of biometrical data (racial analysis) and by extensive tagging programs. The independence of the herring populations between areas, and even within areas, is of particular significance in that it alters entirely the problem of conservation. If the herring along the coast were of one stock, then extensive withdrawals in any of the localities now being exploited would be replaced from that common stock. Since, however, each of these localities is supported by a separate body of fish, over-exploitation in any one area will lead to a decline of that population without chance of replenishment from stocks in other areas. This may lead to a failure of the fishery in that locality without affecting the status of adjoining populations. Any discussion of abundance must hold this as a fundamental premise.

To return to the discussion of the causes for changes in abundance, the first of the factors mentioned above which govern the catches of the fishermen—that of changing availability—may be expected to play an important part in determining the quantity of fish taken from year to year. It must be recognized that the catch for any one year might easily be influenced in part by weather conditions governing the activities of the fleet, or by other causes affecting the behavior pattern of the herring. Therefore, a rise or decline of the catch in a single year over that of the preceding season is not sufficient evidence on which to base any conclusion on abundance. This factor of availability, however, as reflected in the average catch from season to season, tends to be compensatory, since for each season in which adverse conditions have resulted in poor catches, there has been a season in which favorable conditions have led to good yields. Obviously no continuing decline in the catch would result from this factor alone. A trend showing reduced catches continuing over several years, such as has occurred in the important fishing grounds of southeastern Alaska, and which has become evident in the Prince William Sound and even in the Kodiak catches of recent years, can not be ascribed to variations in availability alone.

On the other hand, as the technique of fishing has improved through the years the fish have, in effect, become more available to the fishermen in proportion as improvements have contributed to making the gear more effective. Increased knowledge gained through fishing the same grounds year after year, together with improved methods and equipment have served to increase the effectiveness of the fishing gear. Outstanding improvements have been an increase in size, seaworthiness and speed of vessels, the use of power in handling fishing gear, and the introduction of radiophone equipment. Many another innovation in fishing technique has resulted in increasing the effectiveness of the vessel as a fishing unit. Unlike the hydrographic factors mentioned which govern the availability of the species to the fishermen, which are compensatory, these improvements have been cumulative in their effect. If the abundance of herring had remained constant through the years, one would expect continuing increased catches as a result of these improvements. This has not been the case. Thus it becomes even more apparent that this changing availability can not be held responsible for any long-term fluctuation in abundance, and the declines of recent years can not be attributed to this factor. The fundamental cause of these fluctuations must be sought elsewhere.

The second factor to be considered—that the withdrawals made by man may result in a reduced abundance level—can

not be lightly disregarded. The balance of nature is such that, even without this added withdrawal, the species succeeds only in maintaining itself and does not increase beyond bounds. Natural predators, of which there are many, take a huge toll from the stocks each year. When the demands of man with his highly efficient gear for the capture of herring are added to those of the natural enemies, the result must inevitably be a reduction in the total numbers of individuals of which the stocks are comprised.

The question arises as to whether or not these inroads of man have been a significant factor in bringing about the declines which have been observed. There is considerable evidence to indicate that they have been, and little or none to disprove it. As each new district has been invaded by man, the abundance levels have been found to be high, and in each case have shown positive declines following periods of intensive fishing. The declines, too, have followed a definite pattern. Those areas first and most intensively exploited have been the first to decline; those more recently opened have followed in the same proportion as the intensity of the fishery. It is unmistakably apparent that the withdrawals of the most efficient of all the predators—man—has had a significant effect on the abundance of the species. Until proof to the contrary becomes evident, man must assume his share of the responsibility for the decimated stocks in areas of continued intensive fishing.

The third factor mentioned—that of the natural fluctuations which might be expected to occur quite independently of the fluctuations made by man—have been shown to exist to a marked degree in the herring as well as in many other species of fishes. These fluctuations result from the varying degrees of success which attend the spawning from year to year, so that the young surviving to the age at which they enter the commercial catch may be exceedingly numerous in some years and in other years exceedingly scarce. When the former situation occurs, there follows a marked rise in the abundance level of the stocks involved. This increased abundance level continues until this group has been reduced either from natural or from imposed mortality. Conversely, the failure of any spawning to contribute a normal share to the replacement of stocks reduced by the mortality during the preceding year, leads to a decline in abundance—a decline which may continue until a new successful spawning again replenishes the stocks by the contribution of an abundance of new recruits.

Continuing records of the age of fish present in each year's catch show that this condition applies very clearly to the Alaska herring. Since the age of the individuals can be determined in this species by examination of the scales, it is possible to establish the percentage of the total represented by each age in the adult stocks, and so appraise the contribution made by the offspring of each spawning to the total population. In occasional years the recruits entering the catch appear in great abundance—indicating that an unusually large number of the offspring of that spawning had survived—and this age group continues to constitute a large percentage of the total for several succeeding seasons. The contribution of such a dominant group may be as high as 90 per cent of a season's total catch. It has been demonstrated that in the past fifteen years there have been two such exceptionally successful spawnings (1926 and 1931) and three which were fair producers (1929, 1935 and 1936). The remaining spawnings, especially those of 1928, 1932, 1933, 1934, 1937 and 1938 were mediocre or poor, contributing but little to the stocks. Fig. 2 portrays the age composition of the important Cape Ommaney stock of

the southeastern district for eleven years following 1929.

The distribution of ages shown is typical not only of this stock in southeastern waters but also in those of Prince William Sound and Kodiak. Whatever the factors responsible for the survival of the spawn, they are of such widespread character that they affect the stocks in all districts much alike. It was the offspring of two phenomenally successful spawnings (1926 and 1931) which have largely supported the Alaska herring fisheries since 1929. The fortuitous entrance in 1934 of the offspring of the 1931 spawning, occurring simultaneously with the disappearance of the 1926 year class, bolstered the abundance levels which would otherwise have fallen sharply. With the subsequent decline in abundance of the 1931 year class from natural and man-made mortality to a point at which it was no longer able to contribute a large share to the catch, there followed the decline in abundance of the southeastern fishery which became so evident after 1937. The increments provided by the 1935 and 1936 year classes were not sufficient to check this decline for long, although their contributions served to postpone it. This same condition has been reflected in the catches in Prince William Sound since 1938, and has been felt more recently in the Kodiak area.

While the 1935 and the 1936 spawnings have aided in sustaining the yields of these fisheries with their contributions to the stocks, they alone have not been of adequate numerical strength to fully reimburse the stocks for the withdrawals which have been made, and a continuing decline in yield may be expected until a new abundant age class enters the catch. When this will occur no one can predict, and until such occurrence man must temper his demands on what remains of the stocks in order to insure the survival of a sufficient number of individuals to

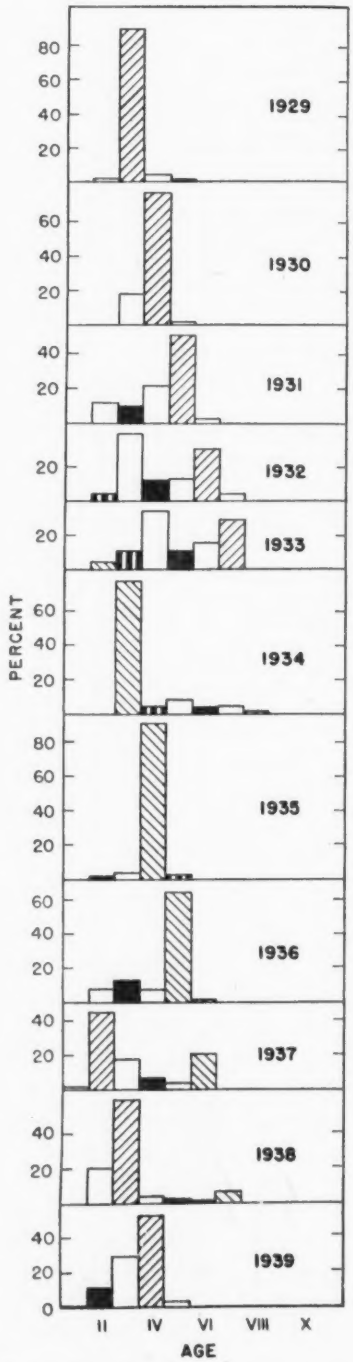


FIG. 2. DOMINANT AGE GROUPS ARE SHOWN IN THIS GRAPH OF THE PERCENTAGE AGE COMPOSITION OF THE HERRING TAKEN AT CAPE OMMANEY IN SOUTHEASTERN ALASKA.

produce a future successful spawning when biotic conditions are favorable to such an event. With the influx of such a group renewed activity can be anticipated in all the fishing areas.

The fourth factor—basic changes in migration patterns of the stocks of herring—if existent would render invalid any evidence of decline based on the reduced catches made by the fishermen on the customary grounds. The reasoning most often used to explain poor catches by those reluctant to accept the possibility that declines in the actual numbers of individuals comprising the stocks have occurred, is that the herring failed to "set in" for one or more years. There is no evidence to support this theory, and much to refute it. As each new area was exploited, the abundance was found to be high; continuing intensive operations have always led to declines. In those instances within our knowledge where reduced population levels have been reestablished at high levels, these increases have followed the entrance into the ranks of the adults of recruits from an exceptionally successful spawning. Each time declines have again followed as these individuals in turn have succumbed to their many enemies. Of recent years it has been demonstrated that nine out of fifteen spawnings have failed to provide adequate replacements to the adult stocks. Declining abundance levels must inevitably follow such an unfavorable replacement record. Thus, with each major fluctuation explainable in terms of abundance, there seems little reason to believe that abrupt changes in migration of the stocks can be held responsible for the declines and failures in the fishery.

It has become ever more apparent as the knowledge of this species has increased that the Alaska herring are not as productive as are other closely related forms. A close relative, the Atlantic herring, has an effective fecundity far above that of this species. The catches of Atlantic herring have been tremendous, yet in most cases there has been no indication of depletion. In this regard Aage J. C. Jensen states in a discussion on the laws of decrease in fish stocks,[1] "Fisheries are everywhere of so high an intensity that few food-fish reach an age at which the natural cause of death would be old age. One exception, however, might exist in a part of the Norwegian spring-herring stock, which is so slowly reduced that even 20-year-old specimens are not at all rare in catches." This is a situation quite different from that of our Alaska fishery, where few individuals attain an age of over eight years, at least in those stocks which are heavily exploited.

The demands of the fishery must, of necessity, be reduced to fit the productive capacity of the species. The size of the harvest which may be reaped without endangering the future spawnings by reducing the stocks too drastically, will be dependent on the effective replacement rate. If the low rate of the past fifteen years be the normal one, then it is quite apparent that continued large withdrawals can not be made. If, on the other hand, nature provides more bountifully in the future by furnishing a series of more successful spawnings, then, and then only, can man increase his take without endangering the supply. Time alone holds the answer.

[1] Conseil Permanent International pour l'Exploration de la Mer; Rapports et Proces-Verbaux Des Reunions. Vol. CX, 1939.

THE SKEPTIC AND THE ENGINEER: A STUDY OF HUME AND WATT

By RUFUS SUTER
LIBRARY OF CONGRESS

WHEN James Watt, a young civil engineer in Glasgow, obtained his first patent on an improved steam-engine in 1769, the librarian David Hume had retired to Edinburgh. Possibly these two Scotchmen never met for Watt had not yet proved his worth, and the popular home which was opened three years later at the corner of St. David Street was reserved for brilliant exponents of the pure intellect. Nobody would have guessed that an impoverished engineer without formal education was about to start an economic revolution to transform the world. If the two had met, if the critic of the scientific outlook and the wielder of the scientific technique had matched their wits, something of importance to the understanding of the nature of science might have resulted.

There was more in common between Hume and Watt than appears on the surface. We may marvel at Hume's versatility. Librarian, historian, philosopher, economist, essayist, diplomat, he was equally at home gathering historical data at the library of the Faculty of Advocates in Edinburgh, or talking with Madame de Pompadour in the court of Louis XV. But Watt also was versatile and not uncultured. It seldom is appreciated that he was trained as a mathematical instrument maker and that his skill in this trade, combined with an interest in astronomy, led to his appointment, while still young, as technician to the Macfarlane Observatory at the University of Glasgow. He was also, one should remember, a co-discoverer of the chemical composition of water along with Priestley and Cavendish.

The significant common ground between Hume and Watt, however, was their inheritance of the British empirical tradition. If we recall the history of English thought we will place Hume at the end of a line beginning with Francis Bacon who gave an empirical interpretation to the methodology of the sciences. Among the men in this line were pioneering scientists like the chemist Boyle and the physicist Newton, and philosophers like Locke and Berkeley who speculated about the sources and limits of knowledge. One and all, they emphasized the value of the senses as avenues to information about nature and themselves. We have spoken of this as the British empirical tradition, which is not quite accurate. The thinker who certainly was the first to ply the new method with unquestionable success was an Italian, the father of modern dynamics, Galileo, whose disciples in Italy (such physicists as Torricelli) gave him lusty support. It is, nevertheless, accurate in general to call empiricism a British movement since on the Continent, west of Italy, in the great universities of the Low Countries and in the élite circles of Paris, scientific thought was dominated by the disciples of Descartes, who sought to base knowledge on a kind of rational intuition rather than on sensory observation. And Galileo, himself, as we shall see later, was an empiricist only in a "loose" sense.

To think of Watt as consciously belonging to either of these traditions may seem paradoxical. A man whose excellence was in doing rather than in reflective thinking will strike one as in

another dimension of activity from that in which such philosophical distinctions have meaning. We have nothing from Watt's quill to indicate that he had the least interest in the struggle between the Cartesians and Newtonians. But it is possible to reconstruct the guiding thought in the back of his mind from his reading.

Here again, however, we can not assign to one tradition or the other. The authors he read: for instance, the Frenchmen Bion[1] and Belidor[2] and the German Leupold,[3] were themselves engineers and mechanics and as unconscious of the basic problems of the theory of knowledge as he. But perhaps one may assume that if these men were influenced by Descartes at all it was only in their use of analytic geometry, which he invented, and in a sympathy with the mechanistic world-view which one branch of his spiritual descendants championed. Newton would have interested them in his work on the theory of gravity, and in his optics.

One book read by Watt was definitely Newtonian. He studied it before he left his father's home, and as a supplement or perhaps impetus to his mechanical and astronomical bent it no doubt left a deep mark upon his youthful mind. This work, an introduction to Newton's experimental philosophy, was by a Dutch professor, 's Gravesande,[4], at the University of Leyden, who had known Newton personally. The English translation, which Watt read, was by another celebrated Newtonian, the French refugee Desaguliers,[5] who was the first popular lecturer on scientific subjects in London.

'S Gravesande's book treated of most topics of interest to the physicist: body, motion, gravity, pressure and resistance of fluids, air as an elastic fluid, refraction and reflection of light, the system of the world, etc. It emphasized the reign of law. What is of particular interest to us, however, is the long preface in which the methodology of Newton is stated in admirably clear and precise language. The function of the scientist, according to this preface, is not to speculate about first causes, the foundation of law, or the substance in which observable properties (the phenomena or "appearances") inhere. His task is to observe the phenomena and by a process of induction to arrive at natural laws. The scientist's concern, in other words, should be with the observable and not with invisible intangible metaphysical abstractions, nor even with *a priori* knowledge of the visible. Even the principles of mathematics have their basis in experience. Nevertheless, the preface commends the classical principles of uni-

[1] Nicolas Bion, 1652–1733. *Traité de la construction et des principaux usages des instruments de mathématiques*, Paris, 1752. Watt read the 1-st ed. of the English translation by Edmund Stone (d. 1768) published in 1753. Stone, who greatly enlarged the original, was a student of Newton's *Principia*, and a member of the Royal Society.

[2] Bernard Forest de Belidor, 1693–1761. *Architecture hydraulique*, 1-re ptie., 2 t., Paris, 1737–39; 2-e ptie., 2 t., Paris, 1750–53.

[3] Jacob Leupold, 1674–1727. *Theatrum machinarum hydraulicarum*, 2 bde. in folio, Leipzig, 1725. Watt learned German to read this.

[4] Willem Jacob Storm van 's Gravesande, 1688–1742. *Physices elementa mathematica experimentis confirmata, sive Introductio ad philosophiam Newtonianam*, Lugduni Batavorum, 1720. This work went through several editions, and was translated into Dutch, English and French. In an age when scholars were either Cartesians or followers of Locke, 's Gravesande championed a midway position. He was elected to membership in the Royal Society while visiting London.

[5] John Theophilus Desaguliers, 1683–1744. *Mathematical Elements of Natural Philosophy*, confirmed by experiments . . . translated into English by J.T.D. London, 1721; 6-th ed., improved by the author, 1747. Watt read this when he was fifteen, thus in about 1751. Desaguliers was held in high esteem by Newton, and was elected to the Royal Society.

The information about Watt's reading was taken from James Patrick Muirhead's *The Life of James Watt*, London, 1858, p. 22, 39, 64, 75, 83. Andrew Carnegie wrote a lively biography, *James Watt*, New York, 1905.

formity and parsimony, and points out that the scientist should be broad-minded enough to admit that substance, though he can never know anything about it, may have properties about which he can know nothing. This is to counter the theory that substance is the sum of observable qualities.

If we grant that Watt was impressed by this preface we may think of him as having inherited along with Hume the British tradition of empiricism. The portrait of Newton[6] which hung in his father's home and which perhaps indicated the direction of the sympathy of the family, was a symbol in another sense of the same legacy.

Now that we have looked at the common ground occupied by Hume and Watt shall we turn to what is a more intriguing consideration from the point of view of the effect of each Scottish thinker on history? We must infer that a critical difference of interpretation of the nature of empiricism itself separated Hume from Watt; and this difference, we shall find, exemplifies vividly the curious dual rôle which empiricism has played in the world of science ever since.

Had Watt been asked whether the iron, coal, fire and steam among which he dwelt were "appearances" he would in all probability have answered "No." "Appearances" are not genuinely real. The hardness which one feels when the hand comes in contact with iron, along with the feeling of warmth when one draws near burning coals, and the sound of the boiling water, pumping piston-rods and revolving wheels when one is in the neighborhood of a steam-engine are real in a sense, but not too real. Such qualities should not be confused with the actual hard substantial facts in the world of mines, blast-furnaces and cotton mills.

Hume on his own testimony recognized this same distinction when he stepped out of his study. But while in his arm-chair he saw the universe differently. Then the question whether iron and steel were analyzable without remainder into "appearances" would have brought an emphatic "Yes," although he would have preferred the word "impressions" to "appearances." That is, Hume while in meditative mood regarded the realm of sense impressions, memory images, images of the fancy, and feelings like hunger and joy as the only world. The other allegedly more real world of coal mines, blast-furnaces and cotton mills is a part of the panorama of psychical entities, is a tapestry the warp and woof of which are threads of consciousness.

Hume's quaint arm-chair speculation was the result of his taking seriously the dictum that all knowledge comes from observation. Suppose we consider the sentence: "Under normal atmospheric pressure water boils at 212 degrees Fahrenheit." This statement is commonly understood to mean what it says, an interpretation which we shall call loose; that is, it is an empirical sentence, but empirical only in a loose sense of empirical. For Hume, however, it would have had a stricter sense. He would have applied to it a hair-splitting literalness, and perhaps for most men would have seemed carping and obstinate. When we say that under normal atmospheric pressure water boils at 212 degrees we mean, according to Hume, that one pattern of sensations called fire, particular readings of the borometer and thermometer, and water at the point of boiling, is followed by another configuration of sensible data including those which we call boiling water. This is our meaning and it is all we know about the situation. Hume took with the ut-

[6] Muirhead, J. P., *op. cit.*, "Among the few articles of household decoration of which the humble mansion of Thomas Watt and his sons could boast, were portraits of John Napier . . . and of Sir Isaac Newton." p. 29.

most Scottish hard-headed literalness the idea that knowledge has its exclusive origin in observation. He refused to understand in such a sentence any meaning beyond what was capable of corroboration in the experience of an observer. For him, consequently, transcendent beings like matter, efficient causation, force and energy drop out of the picture.

Watt, however, along with Desaguliers, Newton and Galileo, understood by empiricism much the same as any practical mechanic or technical student actually dealing with machines and forces would have understood, and would still understand to-day. Machines for a person who handles them are set in motion by a very real force generated in the combustion of coal and the expansion of steam. They exist for the force which they get and give. Such men, if they have any thought of the theory of knowledge, are empiricists because empiricism is a common-sense attitude. They have learned through experience that the only practical way of discovering how forces behave and how they are to be harnessed, and how machines are to be improved and manipulated, is by careful observation over a long period, by experiment, testing, trial and error, and the rest of the battery of empirical methods.

Hume's empiricism, as one might anticipate, was the last stage of a blind alley. His "Treatise,"[7] as he quaintly wrote, was "dead born from the press." If you wish to emphasize the value of observation as a means of knowing you can go no further than to say that nothing exists, as far as you can know, save immediately observed data (patches of color, sounds, smells, etc.). In Hume's hands the empirical tradition, despite its beginnings in the laboratories of mechanics, suddenly became a metaphysical scheme suggesting, as Thomas Huxley once wrote, Buddhism. Such extreme empiricism is poor ground for action, especially for the sort of action upon which there is a premium in an industrial world growing by leaps and bounds.

The future lay with Watt.[8] To try to explain the origins of modern commerce and industry in terms of pre-Humian philosophical empiricism is, no doubt, to oversimplify grossly. The Medici, who patronized Galileo, were already merchant-capitalists on a vast scale, and part of Galileo's personal motivation was sympathy with the economic aims of commercial-minded rulers. He spent years, for instance, in the search for a way to determine longitude at sea—a clear case of business needs instigating research. It is also true, however, that Galileo's purest theoretical researches, his inquiry into the rate of acceleration of falling bodies, turned out to have incalculable value to investigators with the most practical of motives, the engineers. Thus one may say without exaggeration that from the beginning science proved an ally to the development of industry and commerce. This is the case more clearly with Watt, and in this sense one may affirm that the future lay with him. In his hands science became overwhelmingly powerful in the practical world.

Watt grasped the needs of his age. Others besides him could do this, including the business men, which accounts for the comparative ease with which he was able to form a partnership with the wealthy enterpriser Matthew Boulton after his experiments had caused the bankruptcy of an earlier backer. England was awaiting the mastery of a new

[7] *A Treatise of Human Nature: being An Attempt to introduce the experimental Method of Reasoning into Moral Subjects* . . . Book I. Of the Understanding. London, 1739. Note the words "experimental method" in this title. By "moral" is meant "mental" or "pertaining to mind."

[8] Even his name has become a common noun, the watt, which significantly is the name of the practical unit of power.

Watt was elected to the Royal Society in 1785, an honor which never fell to Hume.

brand of mechanical energy. Consider the plight of the coal mines in Cornwall. They had become important since the exhaustion of the forests for the supplying of fuel in the blast-furnaces of the iron industry; but unfortunately flooding had made them unworkable. Exploiters of steam before Watt: Savery with his Miner's Friend and Newcomen with his Atmospheric[9] had attacked this problem, but their pumps were hopelessly uneconomical. They pointed, nevertheless, in the right direction. Watt's first steam-engines were also pumps, and what the business men had shrewdly foreseen happened in little more than a decade: these improved pumps saved the mines. Another need for a prime-mover was in the rapidly growing textile industry, the leader of which, Sir Richard Arkwright, had patented a spinning frame. This was destined to change the once pastural England into a factory-nation as soon as a source of energy independent of geographical location (of water-falls, for instance) was harnessed. Watt's engines, now advanced beyond the pump stage and equipped with rotary motion (also his invention) so that they could drive machinery, filled this bill. England was ready for Watt. But this should not cause us to forget that he was a scientist, an heir of the tradition of genius flowing from Galileo, Gilbert, Boyle and Newton. When we say that his invention was a chief factor in ushering in the Industrial Revolution we are justified in adding that the scientific outlook loosely understood (interpreted not in the way of Hume) was a chief factor.

The moral of this sketch would be plainer if we expressed more succinctly the fortunate combination of interests, aside from the economic situation, which made science possible as a force. This would be in terms of the words "strict" and "loose." The scientists from Galileo to Watt failed to distinguish between the strict and loose scientific outlooks. They did not consider whether it was possible to have immediate empirical experience of matter and force; that is, directly to prove their existence by observation and experiment. Again they failed to consider whether there was empirical justification for their confining their attention to one area only of empirical data: size, figure, mass and motion, the qualities amenable to mathematical treatment. If they had been critical in these two respects, if they had turned the spotlight of their technical methods of operation upon the ideals guiding their choice of what should be accepted as real and as representative of the real, they would have come to the same impasse as did Hume. Instead, however, they pursued the indulgent course. They uncritically abided by the Cartesian mechanized reinterpretation of the old Aristotelian efficient cause and by the Democritean atoms, and they gave to shape and the other primary qualities a capacity for reflecting reality which they denied for instance to smell. Because of this loose thinking they transformed the world.

[9] Desaguliers, also, in 1721 set up a steam pump in his London home.

PROPAGANDA AND THE DEMOCRATIC STATE

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Mass beliefs are the most striking phenomena in modern civilization. To control them is the most important function in the state. Knowledge of even a few of the laws that govern the development of beliefs is highly desirable. The unhappy changes that have taken place in three great European countries evidence the close linkage of the welfare of a nation with the use or abuse of persuasion. Common elements may be detected in the methods employed in all three countries and in the course of the change in sentiment. In Russia, Italy and Germany hate was developed in the mass of opinion, against the established order. In Russia the theoretical object of the hatred was the industrial order, but there was a background of revolt against the autocratic rule of the Czars. In Italy the object of the revolt was the socialist worker domination of industry that had proven itself incompetent. Here again a large element in the emotion was a revival of the greatness of the Roman Empire. In Germany the object of hate was the Versailles treaty, especially the derogation of the dignity of the German people. Minor hates were toward the Jews and the government, both, it was alleged, because of blame for losing the war. Economic factors were not mentioned, although the general economic depression, following the war, inflation and later retrogression of industry was a contributory element, without doubt.

In each country, the movement gave power to a leader. In each instance the leader when in power forgot his beneficent intention and threw over all signs of a democratic control in politics. In varying degrees he took charge of the economic life of the community, expropriating many of the industries from former owners. The new leader did not hesitate to murder his opponents and in time many of his early supporters and to appropriate all the power and most of the wealth at the expense of both capital and labor. In no one of the three countries were the promises of a more liberal rule kept. The fine phrases that had served as slogans in the overthrow of the old régime were kept only as a sop to reduce the discontent of the ruled with the new order. In each instance the leader who won was a man with little that would mark him for the position. Lenin was one of many revolutionists who had fallen under the notice of the authorities and been compelled to go into exile. Mussolini was an editor and a leader of a socialist group, but he had no great following in politics.

Hitler was a man who seemed still less likely to attain leadership—an unsuccessful artist who seems to have earned a precarious livelihood by odd jobs of house painting after the war. There is some evidence that he is a hysteric. At least a member of the Heidelberg medical faculty was sent to a concentration camp for saying that Hitler escaped service in the first world war by hysterical blindness. Hitler himself gives confirmatory evidence in his speech comparing his hard life with Roosevelt's opulence. He states that he was blind for a time and recovered. Hysteria is one of the few causes of a blindness that may be recovered from spontaneously. To add to his handicaps Hitler was an Austrian and so a foreigner. Despite all, Hitler marched on to power. The prison sentence for the Munich attempted revolt gave a chance to write "Mein Kampf." His eloquence and

audacity accomplished the rest. He finally obtained, next to the communists, the largest number of votes in an election. Hindenburg feared the plan of von Schleicher to divide the East Prussian estates, one of which he held, and made Hitler chancellor. Once in power, Hitler abolished all but the form of the Reichstag and took complete power for himself. Even the army did not oppose the move, although he was repugnant to all their class and professional traditions. The methods by which a single man can dominate a nation offer a problem of the greatest interest. It can be considered in part as a phenomenon of the crowd in relation to a leader. From another aspect it indicates the type of proof that may be accepted by an audience or a wider group, especially of how far conviction is of what we call a rational character and how far it is dominated by emotion. Even if the analysis can not at present be complete, enumeration of some of the known factors are of value. Democracy depends upon a control of these forces. Domination of a nation by a single individual, even if he at first has the best of intentions, ultimately leads to the destruction of freedom.

All agree that a man in a group has a different character from the same man alone. The degrees of difference vary with the size of the group and the occasion. Le Bon asserted that a man in a crowd becomes as a man hypnotized. He loses his capacity for decision, his intelligence is reduced, he becomes more emotional, he feels rather than thinks. Even an audience under the control of emotional speakers may show some of these characteristics. Hitler in "Mein Kampf" asserts that the man in an audience is of a mental age of eight, that you can not reason with an audience, you can only arouse the emotions. A mob as it starts on an illegal errand such as a lynching, or any even minor riot shows the same tendency. Any idea that is suggested will lead to excesses that the same men in their sober moments would repudiate. At the least the man in the audience is too ready to believe what he hears. An illustration is Borah's statement a little before he died. He was asked if he had heard the President's speech on foreign policy on one occasion. He replied "No. I do not dare listen to Mr. Roosevelt. I can't trust myself not to believe him, and always regret it later."

One might urge that the orator who plays upon the crowd may also go into a sort of trance. Rauschnig, a careful observer of Hitler, made the statement that he could talk fluently only when he worked himself into an emotional condition allied to frenzy. When he was addressed casually on ordinary questions, he was reticent. He seemed to have difficulty in answering a question. When he desired to give an answer he seemed to go through an intentional process of developing an emotion. Then he gradually showed an intensity of response that was altogether beyond that appropriate to the size of his audience. He spoke as if another were speaking through him. A chance to analyze the character of the orator's state of possession would be valuable and should throw light upon several problems of the orator and the crowd. One can not charge every man addressing an audience with being in an even slightly abnormal condition, but as we have seen, there are indications that some are. Most speakers who are at all facile probably respond better when speaking to an audience than when alone and some do markedly better. The difference between such a mild stimulation and the frenzy-like state of Hitler is very great, probably is more than a difference in degree.

One can see exaggerations of this response to the crowd in individuals who are definitely insane. A man who had the background of a clergyman in a Protestant church and who later was a C.I.O. labor leader experienced an attack of circular insanity. In the excited

phase when presented to a class he began an eloquent oration or sermon on a religious topic. The tones were of the pulpit and the topic was religious rather than of the later labor phase of his career. The mental processes were not orderly, but the form was characteristic of the orator. Not too much should be made of this as an indication of the possible abnormality of the speaker in general. Any habitual activity is likely to be prominent in the activity of the insane. The presence of a group served to start the speaking reactions with full gusto, and they were carried through with complete assurance and with effectiveness of manner. That an insane man in a period of exaltation falls into the habitual response of the orator, does not prove that the orator is necessarily abnormal, but merely that even insanity is not incompatible with the speaking response.

The action of the speaker on the audience, and the general interaction of a man upon other men, is fundamental to the development of social life of all forms, including the economic. The action of the speaker on the audience is the best illustration, but the influence of the written word in press and in books and in recent years the influence of the radio is equally important. The use of words in moving mass opinion is propaganda. Propaganda depends upon the laws of social psychology or would if the laws of social psychology were fully known. The first law is that the mass to be impressed should be made or induced to transform itself into a crowd or a mob. It must be unified to the degree that all think, and still more, feel in unison. A criterion of this condition is hard to obtain. It seems not to be identical with intellectual approval, or at least less connected than one would think at first sight. In listening to an address man is only in part a rational being. Much more is he controlled by emotion, and the previous attitudes that he has built up.

Argument implies the use of facts and deductions from facts by accepted logical means to establish truth. Propaganda suggests that a conclusion that it is desired to establish is untrue or at least not quite above criticism. Propaganda is at best an argument by one in whom the speaker does not quite believe, and the term suggests that the methods of proof used are open to suspicion. One uses it of the political moves of an enemy in influencing neutral opinion or in seeking to undermine the loyalty of one's allies or one's own citizens. In a political campaign it is a not quite straightforward use of arguments, or the use of false statistics in establishing a point. It may involve fallacies, it is also used for arguments not demonstrably false in which emotion rather than fact dominates.

Justifiable argument, on the other hand, relies upon relating the conclusion that the speaker tries to establish to accepted and completely established principles. Sometimes, but that is rare, a statement may refer to a definite fact that can be established by witnesses. Most argument relies upon mentioning more or less closely related facts or principles that are known to or accepted by the person to be convinced and showing him that the conclusion to be established is of the same class or follows directly from the facts or principles that are mentioned and accepted. In general it may be asserted that belief comes from a reaction of what one already knows upon any new statement. When there is consistency between past knowledge and the assertion that is proposed for acceptance, belief develops; when the new conclusion suggested is not in harmony with what is already known, it is rejected. Argument consists in bringing to the fore the phases of experience that are in harmony with the conclusion the pleader desires to have the audience accept. If it succeeds belief spreads from the accepted to the new and that

too is believed. We need not go into the details of the theory of proof. Proof by this means appears to constitute the essential factor in what we ordinarily know as logical proof.

However, much of the conviction attained in any discussion is not to be referred to pure transfer of belief from the already accepted to the proposition to be established. Much even in formal logic syllogisms depends upon indirect influences, upon what Woodworth has called halo effects. Many of the recognized fallacies of logic can be referred to the influence of word or propositions that are implied but not stated by the words. One confuses some with all. One takes words suggested by the words used for the words themselves. The intellectual processes are themselves dependent upon influences that are not supposed to determine the decision to be made.

More striking is it that factors that would be classed as emotional rather than intellectual exert an important influence on the decision. Evidence for this has accumulated both from common observation and from tests of different kinds. One may quote Hitler for the results of a general impression. He, among living men, has made most use of propaganda for political purpose and has been most frank and cynical in stating his conclusions. Hitler asserts over and over that what counts with an audience is not reason but emotion. He reiterates that the discussions of the social democrats who dominated Germany for a dozen years before he came to power were entirely of a factual, rational character. The conclusions that they favored were stated with logical precision and based upon facts established fully by statistical methods, but they failed to have any influence because they were entirely lacking in emotional appeal. Similar statements are made by Chen as a result of experimental studies on changes in student opinion on the Manchurian question under the influence of factual as compared with emotional appeals. He found that attitudes as measured by replies to a questionnaire were changed markedly more by an emotional appeal than by the factual statements.

Possibly the most direct evidence was an experiment by Lund on the relation between the pleasantness of a proposition and the tendency to believe it. Lund's method was to ask students in different universities to grade a series of propositions first for their pleasantness and then as to the willingness to accept them as true. The propositions covered a wide range in religion, politics and ethics. When he plotted a curve of degree of pleasantness and compared it with a curve of the acceptance as true of the same proposition, he found that the two curves overlapped in a large extent of their course. The coefficient of correlation between the pleasure aroused by a proposition and the amount of belief showed a coefficient of correlation of more than + .80, a very significant correspondence. If this be taken as fully justified it would mean that wishful thinking is the rule rather than the exception. That one thinks what would be agreeable and then accepts the agreeable as true.

Evidence is also accumulated that of the feeling or emotional processes, hate or anger is more effective than admiration or love in the arousal of belief and is especially effective in arousing to action as a result of belief. Again we can turn to Hitler for the practical illustration, most striking in recent times. Hitler shows in "Mein Kampf" that a constant reiteration of reasons for hating another group or a cause arouses the hearers of a group against them. Exciting hates in this way will unite the group that hates into a common mass that may make them think and act together. Hitler aroused his group and developed the national socialist party by expressing the common resentment of the German people against the Versailles treaty. This was associated with regret over the

lost war, the memories of the sufferings during the war, the economic decline of Germany that followed the war and the inflation which was permitted by the parties that governed Germany in the years that followed. The whole series of events developed a feeling of inferiority and uncertainty in the German people, directly in contrast to the overbearing attitude in the imperial period. It was all the more disheartening because of the previous exaltation.

A more personal hatred was turned towards the Jews. This was again a case of increasing a race prejudice that was fairly wide-spread in Germany. It was partly a holdover from medieval times when it was expressed by isolation in the ghetto, partly it was rearoused through competition with the Gallician and other Jews who migrated to Germany from the more eastern Slavic countries after the war. This hatred was tied to the resentment over the war results with the statement that the Jews are responsible for losing the war. Of course the reasons assigned were not adequate for proof. This again harmonizes with Hitler's general thesis that the hearer is really moved by emotion, not by evidence. Tying responsibility for losing the war to the Jew was an added stimulus to hatred towards him. The weakness of the evidence was considered by no one except the Jew himself and his friends. Apology for him did not count in connection with Hitler's purpose. Any man who wants to advance a cause or form a party finds it very much more effective to turn the hatred of the group to a man they want to oppose than to praise the man or cause they seek to favor. Societies and groups are held together more firmly by common hates than by common loyalties or loves.

Study of propaganda in any form bears this out. Lasswell and Blumenstock have given a detailed account of the methods used by communists in Chicago during the early years of the depression in which the use of hate comes out very clearly. This, like Hitler's campaign, was definitely an attempt to induce a revolution in America of the Russian pattern. In all the maneuvers, emphasis was placed upon the imagined responsibility of definite individuals for the deprivations of the people. No instances in their appeals are found in which they state that the Russian worker was in a better condition. The facts would not support that statement. For propagandists that would be no bar to the statement. All banners and slogans referred merely to the difficulties of the lower income groups in America with the charge that the bosses are responsible. Much use was made of the words starvation, bloody bosses, oppression, police brutality, all designed to raise the emotions of pity for the victims and then hate for the individuals who are assumed to be responsible. There was no demonstration that the connection asserted really existed, and no discussion of a possible remedy. The emotion is essential. Coupled with the hatred of the present state is the assumption that a change in government or the destruction of the capitalist system will at once prove a cure-all for the difficulties.

Laying the Basis for Belief or Attitudes

We have said that proof in dealing with an audience or in a treatise is a process of pointing out the aspects of the position that you desire to establish that harmonize with the fundamental beliefs of the audience or with experiences common to all. Obviously the next question that arises is how did the fundamental principles that are used in arguments themselves become established. Or from the practical side, if you desire to convert a community or a nation, how can you inculcate the basic axioms that are to be used in later arguments? It should be said that political and economic matters are involved in our discussion, although analysis might show that many so-called rational and moral

principles have been inculcated in very much the same way. At any given time there is a body of beliefs stated in aphorisms or formulae that can be counted on to be accepted in the great social body. Some of them embody common experience. We can leave out the groups that depend upon verified scientific observation and its laws, although a sceptic who observes the changes in scientific formulations from year to year or from generation to generation may question whether all that is taught as science is free from the domination of tradition.

Establishing these principles is more fundamental than the mere arguments of the orator, in fact the effectiveness of the orator depends upon them. One can trace the principles by studying changes in the beliefs of social groups as they occur spontaneously or by the intent of the leaders. Psychologists have also made a few studies of short range changes in sentiments in children and students from seeing movies or from stories and arguments. Both methods of approach leave much to be desired alone, but the results from each confirm the other and check with common observation. The results indicate that what is accepted is a matter in part of mere repetition, in part they are dependent upon the social group by whom the statements are made, in part they are dependent upon purely emotional elements. They may also have a pragmatic test, they work or seem to work, although it is surprising how many statements and practices have been accepted as true through the ages that did not work and might easily be seen not to have worked —the use of charms for cures or even bleedings and similar surgical practices. Except under carefully controlled measurements and records, the measure of success has been very little applied and much that obviously is not effective continues to be believed.

Tracing the growth of beliefs is a fascinating subject and should offer many rewards in understanding the completed mass of doctrines of a community large or small. The radical thinkers in America assert that the school books are responsible for our economic faith and would change the books to establish a new faith. They assert that the founding fathers were men of means and in consequence assumed the sacredness of property, the desirability of frugality and honesty and the right of an owner or manager to direct his own business. Coupled with these are aphorisms about the American way of life that are familiar to all, but that might be difficult to enumerate from their very familiarity. For this the liberal group would substitute the familiar Marxian principles that the framers of the constitution were grasping members of the exploiting classes and that the constitution and the laws based upon it were framed for the express purpose of keeping the laboring classes in subjection. These principles are said by the American Legion to be embodied in widely used texts of social science. The charge is that the author has changed fundamental statements to give a communist bias to the teachings.

That school textbooks are important in establishing certain beliefs as axioms is obvious. Each revolution revises the texts in the light of its doctrines. It is said the primary reader in Mexico introduced by the revolutionary government had a picture of a Ford assembly line with men with whips standing over the workers. When a Russian first reader was adopted for use in an American university certain pages were carefully cut out. It is to be assumed that it was to prevent the students from knowing what the propaganda of the soviet was, rather than to avoid converting them to the Stalin philosophy. To write the elementary textbooks of a nation would exert an influence, possibly a determining influence upon the social axioms of that nation.

In general it seems that the processes by which attitudes are developed or principles that shall be accepted in a com-

munity are established as axioms can be traced to a few relatively simple procedures. One of the easiest is persistent repetition, especially by a respected source. Many of the accepted moral precepts are established in the family by hearing them over and over, with an occasional punishment for failure to follow them. The parents lend their authority to the repetition. The church and school add their influence when the child is older. On the whole it is repetition in an atmosphere for well wishing that gives strength to the admonition.

In addition there are many obviously emotional elements. We have mentioned close correlation between pleasure and belief. A principle that is pleasant to the listener can be accepted much more quickly than one that is not. The bolshevist statement that only the man without resources deserves any place in the state won acclaim from the vast majority who belonged to that class. These men would not have accorded acceptance to a doctrine that hailed the importance of the man of high intelligence or the minor capitalists of a community. The German is willing to accept the belief that all Aryans are superior. It is pleasant to be a superman. The boys of fifteen or so to whom Hitler gave brown shirts and told that they were the hope of the nation and that they and the nation would prosper together, believed the statement in part because it was pleasant to believe.

The play upon hate is equally strong. To believe that the owner of property who may seem so arrogant is really a man who has profited at the expense of all like himself raised a burn in the breast of the Russian that prepared him to murder and loot with an assurance of virtue that mere belief in his own importance would not have justified. When glorification of himself and hate of the possible opponent are active, the development of beliefs that may become the axioms of national or group thinking is easy. We see them in the patriotic assumptions of all countries and we can see how easy they are to transform in the development of the Russian and Nazi movements. In both many of the doctrines that for ages have been accepted by the larger group were overthrown in a few years by studied propaganda. The social and moral axioms can be changed more readily in the young as can be seen in the black shirt fascist groups and brown shirts of Hitler, but the Russian revolution worked mainly with adults. All ages are susceptible to strong influences that work upon the individuals in an accepted milieu.

This is little more than a sketch of what needs to be done if we are to understand the forces that drive modern society. The basis for the control of a social group must begin by developing axioms of what is right and wrong. The simplest way to get them accepted is by repetitions of phrases and of acts that embody them. Those will be accepted that please the group. Wishful thinking is fundamental to the establishment of attitudes. These require a long time to establish and the instruction must begin at an early age if it is to be effective. Canadian officers in control of a German prison camp in Ontario say that men in their late teens and early twenties are ardent Nazis, the older men are sceptical. Expectation of personal advantage and hatred for the men who oppose are essential to give warmth to the axioms.

When these principles or axioms are established by repetition in word and deed, they become the foundation for the work of the orator. Reference to them wakens belief for new propositions that can be shown to harmonize with them. They furnish the unseen basis of later social movements. Morale comes to a group when it accepts a mass of common beliefs or emotional axioms and the group can be roused to enthusiasm for expected results, or can be roused to hatred of the opposing group or the upholders of other principles.

CAN SCIENCE ENTER THE SOCIETAL RANGE?

By Dr. A. G. KELLER

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THIS question demands, for its useful consideration, a ruthless clearing of the ground; it must be realized once and for all that as yet nothing worthy of the name of science exists within the societal range. Every candid student knows that "sociology" languishes in a well-deserved disrepute. A not unfriendly, though somewhat patronizing judgment[1] avers that it covers whatever is left over by economics and political science. There is ample warrant for dropping the term "sociology," had the Greek any other available term to offer. For a name should allocate and draw boundaries. If one is studying petrology, he knows what he is doing and so does everybody else. He does not, and they do not, when he professes the "science of the social."

But let us accept this unhappy situation as, at any rate for the present, irremediable, and take refuge, with Pareto, in letting names go hang and attending to things.

That we sorely need a science of society upon which to rest in our effort to get along together, is evident even to a fool. Nothing has happened in over sixty years to invalidate the chapter on that need in Spencer's "Study of Sociology."[2] It is always the same old, the same pressing, the same unfulfilled need. Supposing men had, to govern their social dealings, anything remotely similar to what they possess, to guide their enterprises in the range of material culture, in the science of chemistry—what a relief of confusion and error would the race experience! As it is there is nothing much to restrain mankind from acclaiming and following, over and over again, and always with fresh hope, any social perpetual-motion fanatic or gabbling medicine-man. Men remain credulous, especially when they are in trouble, because there is no touchstone upon which to rub what is urged upon them. There is need for such a touchstone in order to become critical and discriminating. And the only reliable stone is the one available, and also in daily and unquestioned use in the material realm, namely, science.

The demand for a genuine science of society is rooted in two considerations: first, men must always struggle to live; and, second, their struggle must always be pursued in association with their fellows.

However philosophically debatable the question whether life is worth living, it is a safe bet that the issue of the argument will never be wholesale suicide. "The first task of life is to live," and nature has implanted an instinct, in men as in animals, to see that the task is not evaded. That fact is not to be set aside because now and then some individual chooses death in preference to some other ill that seems to him greater. When death is risked, it is usually in the hope of life. Men are going on trying to keep alive, just as they have done from the outset.

And they are going to do so together, not apart. Whether they have a "herd-instinct" or whether the world is not big enough for a billion Crusoes, so that men have to live in association whether or not they want to, the fact of associa-

[1] A. A. Berle, reviewing T. Arnold's "Symbols of Government," in *Yale Review*, summer number, 1936.

[2] Published in 1874, chapter I.

tion remains. The human effort to live is going to be pursued conjointly.

Beings who are going to keep on trying to live, and to live in society, must likewise keep on seeking the best way to do so. They need to know how to live in association. History records an endless series of tentatives in the *how* of living together. Some of them have failed and been eliminated promptly. Others have persisted. The only generality we can be sure of is that the issue has been decided, in all cases, by experience. That is why tested experience is the surest guide there is.

The verdict of experience may be rendered in terse, sharp and compelling terms, or it may be involved, cryptic and ambiguous. A number of tribesmen eat of some deadly fungus and all who have eaten die; then the terrified rest clap a taboo upon that outreaching toward a wider food-supply. Candles are speedily discarded in favor of oil-lamps, lamps for gas-jets, jets for electric bulbs. A little experience, when crystal-clear, convinces as to which are best for living. The appeal is to "common sense."

But not all cases are so plain. An epidemic following the appearance of something unfamiliar—say, a comet—has often been attributed to the heavenly visitor; the accuracy of the white man's rifle has been accounted for by magic. We think such attributions childish, knowing from experience that smallpox is independent of astronomical happenings, and all about rifling, sighting and wind-gauging. That is because we have a great deal of accumulated experience to go on that simpler civilization has not acquired, recorded and worked over.

Evidently "native common sense" can go some considerable way in enabling mankind to profit by experience, but by no means the whole distance. It is more at home in dealing with things—things that can be handled, weighed, measured, cut up, pulverized or destroyed—inanimate things, plants and animals—in the main, also, things that stay the same, as iron always remains iron or an onion an onion, in distinction from *varium et mutabile femina* or the religion that needs, we are told, a new definition once in so often or the chameleon-like "right" or "justice." Can "plain common sense" pass upon such proposed innovations as birth control, Christian Science, the lottery, socialism, the New Deal? Evidently not.

In dealing even with material things, "native common sense" has been forced to refine itself. It has become what Huxley said science is: "trained and organized common sense." In refining itself into science, common sense has had to drop a good many childish tricks, along with the acquiring of a deal of self-discipline, meanwhile preserving and developing the sterling traits of its character. It has had to renounce wishful thinking, metaphysical day-dreaming and religious dogma, and get down to brass tacks in the cultivation of its affinity for and acquaintance with experience, also in learning how to handle facts of experience so as to evoke from them the maximum quantity and quality of knowledge. In the laboratory it has developed an efficient instrument of experimentation, which is the staging of experience under varying conditions. It has produced the expert. Let no one fail to realize that experience, experiment and expert are blood-brothers, all deriving their being from the same primeval common sense.

Science is not science unless it "makes sense," and nothing nonsensical can be scientific. "Native common sense" usually senses the sense in what science, its refined progeny, does, just as it speedily comes to harbor contempt for the results of pseudoscience. It is hopeful to see the "common man" put his life and money upon the reliability of the chemist while he jeers at the emo-

tional utopian—after a time, at least, and even though he has cheered for a charlatan and followed him awhile.

Let us look for a moment at the likeness in method between common sense and science. Both rest upon experience as the one sure basis. Both gather facts of experience, compare and weigh them, and out of them formulate rules of action. Both forecast the future on the basis of anticipated recurrence, that is, by expecting things to recur about as they have occurred, and not otherwise—conditions remaining similar. The only real difference is that common sense acts more casually, with less premeditation and preparation, more sketchily, more forgetfully, where its refined version has been trained and organized and recorded and systematized. But the essential processes are the same in both. Among the practices they have in common is the immediate rejection of any course not verified, or no longer verifiable, by experience.

Verification on experience is much easier, speedier and more compelling in some ranges of man's life in society than in others. That is why, where they have been dealing with material culture, men have worked out into science, while still far short of science in their handling of the institutions of society—property, government, religion, marriage and the family. Though the line of distinction between natural science and social science is not always sharp, as types the two are readily recognizable and distinguishable, and may be set in contrast without doing any violence to the truth.

In the societal range, as well as in the physical, there has prevailed the same necessity of trying to live on—instead of committing group-suicide. Men have to keep on trying; and they want to waste as little time and to suffer as little from dashing into blind alleys as possible. There can be no dissent about that. They have never desired to make mistakes or to act nonsensically or to sin or to do anything else except what is expedient. They want good social experts so ardently that they have deified many a quack and scalawag who was lucky enough to profit by some coincidence between his promises and the course of events.

Always, in social living, "something has got to be done," and right away. Men are readily persuaded of this necessity, and it is often real. This was once the case in the now accredited sciences. The medicine-doctor sweated the evil spirit out of a sick man, so that he got well. "I work miracles, and by Gott! dey come off, too." All the sciences have had to make their way in the face of slapdash stabs, wholly irrational in theory, that seemed to bring about results—and sometimes accidentally did, by reason of some latent virtue, irrelevant to theory, that resided in them. Science had to put up with such coincidences on the surface of things, working away the while upon the solid and rational foundation of truly verified experience.

In default of guiding principles, random tentatives have to be made until the substructure of principles and laws can be laid. It must be so, in the social range, for a long time yet. No fault is here found with the tentatives cautiously, or even incautiously, launched by those who, on the firing line, have been convinced that they must do something on the basis of native common sense, buttressed, perhaps, by prayer. They have not been able to wait for the training process. There is no blame for any of these enterprises, whether failures or not, so long as their initiators have used all the knowledge available, and disingenuously.

But any person of sense will agree with the foregoing contention, that if we had a science of society even approximating from afar off the science of chemistry,

we should be so much better off that this world would be indeed almost a new one. Why not try, then, to have such a science, instead of either drooping in dejection or stabbing about aimlessly in an ecstasy of untrustworthy noble intentions?

If we are going to try to have a science of society, how are we to go about it? If you note that a certain player generally wins, you want to learn how he does it, do you not? Let it first be sadly but honestly recognized that we may never attain a genuine science within the societal range. There are for us many lions in the path. But there is only the one path, lions or not, that has ever led to the kind of trained and organized common sense in which people show confidence—by act, if not by word, and even when they repudiate it in their words. It is to be noted that even the *precieux* who daintily sniffs at science as a materialistic, vulgar, crawling thing, yet sends speedily for the doctor when he is ill. He even pounds out his fastidious tremors on a typewriter that would not have been except for the sweating miner, the soiled artisan and the low-minded inventor, all henchmen of science.

There is, I say, only one road that has ever led to science. It is the part of sense to take that road. The way to get another science is to learn how the ones we have were got, and then duplicate the process as we can. There is no sense in any other procedure—that is, if we want a genuine science. If we are content to go on with the wishful thinking, intuition, introspection, logic-grinding and thin speculation that have characterized the bulk of existing treatises on society, that is another matter. In that direction lies the chance to maintain for "sociology" its present reputation for triviality, emptiness and pretentious unreliability.

Any one who wants to participate in developing a genuine science of society must steel his soul to renunciation. He is going to see no startling results within his lifetime. He is not destined to attain acclaim. He is like the caisson-builder laboring, down there under the surface, at laying solid foundations for piers that may some time rise—that will assuredly not stand, if they do rise, unless the substructure is arduously, honestly and conscientiously laid.

Pareto warns that the student of society must not be in a hurry about practical results. What he is advocating is, in a word, an austere, detached attention to the development of a pure science. Any such advice can never be popular, for it has never yet broken over men's minds that pure science is the most practical thing in the world. Scientific theorizing, pregnant with eventual benefits, is still confused with the speculation, the intuition and the yearning, just as scientific confidence in anticipated recurrence is identified with faith in divination or revelation. Many another besides Mr. Bryan is totally in the dark as regards the distinction between an hypothesis and a guess—the latter being the former minus data. Scientists of note have promoted this misapprehension by pontificating about matters quite outside the orbits of their special knowledge, thus betraying science to enemies who eagerly welcome and flatter antagonists who are corruptible by a cheap bribe of publicity.

If this generation does not need a science of society, no generation in the world's history has ever needed it. I shall not seek to labor the point in this era of big medicine. I shall merely suggest once again the relief and solace that all the nations would experience could they have recourse, in their welter of uncertainty, conflicting counsel, apprehension and despair, to a universally recognized set of verified sequences and laws such as that possessed by the laboratory sciences. And I do not despair of

the eventual attainment of something of the sort, comparable in spirit if not in perfection of technique, providing that enough devoted young men are led in the present and future to renounce acclaim as the begetters of bright ideas, nostrums and utopias in favor of a long-range program of obscure toil in building upon the solid under-structure of verified experience. "Hasty conclusion easy to make, like hole in water."

I may have been unduly discouraging in citing the laboratory sciences as models for the social sciences. It may well be that their techniques can never be duplicated within the societal range. Let me alter my formula: if mankind had a science even remotely comparable in its rigor and laws to other natural sciences than those of the laboratory—say, meteorology—the millennium would be many a parasang nearer. For these less exact disciplines have, at any rate, one element in common with the strictest sciences, namely, the scientific attitude.

For one thing, they remain unemotional. The meteorologist does not faint away in disillusionment and despair because a storm is indicated when he prefers fair weather. He coolly observes, then verifies and records his observations, without either tears or hosannas. He does not propose to change the nature of the weather (as some social experts propose to change human nature), but only to know about it. His personal wishes in the matter form no factor in his forecasts. He remains detached, dispassionate, objective. He is a weather-observer, not a rain-doctor. He has no rattle, no jargon, no persuasive oratory. He makes no passes.

If the student of social phenomena could do no more than assume that kind of attitude until it becomes with him a settled habit, he would have made a mighty stride ahead. If he finds the laboratory technique beyond him, as it probably always will be, but yet can qualify to take his place in the company of the biologist or geologist, without causing them to draw away as from contamination, he will be scientist enough for earthly purposes.

The first thing to do is to get the materials for the substructure together. That is what many an obscure student was doing prior to Darwin's architectural feat. Few of his forerunning contributors, without whose labors he could not have built his superstructure, had even the remotest idea of the general bearing of what they were about. Somebody became interested in pigeons. He thought, talked and lived pigeons, counted the feathers in their tails, recorded every minute detail he had lovingly observed, sent his results to some pigeon-fanciers' journal, and died. Then, in the fullness of time, along came the man with the synthesizing mind, endowed also with a colossal industry. He grasped and put together the toilsome observations of the pigeon-lover, the horticulturist, the entomologist, and expressed from a mass of verified experience an endlessly enlightening theory of adjustment. In some such manner, and in no other, there may sometime evolve a true science of society. It will never come by "thinking things out." That is the way to get a product resembling astrology or alchemy, the product which we actually have, and which is no credit to us. A science can not be "thought out." It must be worked out. This is no precept of "methodology." It is a piece of common sense.

Justice Cardozo has stated the case of the whole science of society in what he says of law: "Law is not an exact science. There the matter ends, if we are willing there to end it. Exactness may be impossible, but it is not enough to cause the mind to acquiesce in incoherence."

ANIMAL POPULATION CYCLES

By Dr. W. C. ALLEE

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ELTON'S monographic study[1] of populations of mouse-like rodents and their ecological associates would be noteworthy under any conditions; when considered as a contribution from war-time England and published there in 1942, it becomes downright impressive. While the major emphasis is on population study as such, the possible economic importance is never far below the surface. In the grain fields of Europe, the devastations produced by voles and mice often assume high economic importance; hence the study is not unrelated to "war research." In fact, in 1939 the whole organization for the study of animal populations which the author had built up was turned to the protection of food from rodents as a phase of the defense of Britain.

The pattern of treatment in the book is readily described. The first fifth is devoted to setting out the scale of the problems of populations of field mice in relation to European human affairs. This is an ecological problem which centers in the increase and decrease of population density. Research on the European continent has as yet done little to unravel the factors which underlie the more-or-less periodic increases in population density of these rodents, and the factors which produce the recurrent decreases have been partially concealed by attempted control measures. The effects produced by efforts directed towards population control have not been adequately described and hence defy analysis. One feature does stand out: whatever is or is not done by man, there is a natural termination to each period of abundance. The chapter devoted to Russian research on the ecology of animal populations is particularly useful not only because the intense activity of their scientists and the scope of their research program match the continental size of the Soviet Union but also because the published results are so largely a closed book to most scholars.

The author then gives a one-chapter survey of conditions elsewhere, especially in Australia and temperate North America where, despite the use of poison bait, human control measures are said to have been even more negligible in effect and, in North America, natural predators have been more important than in Europe. There follows an analysis of two vole plagues in Great Britain in which there was a minimum of human interference. These are described in some detail together with a rather full outline of the developing research program on the dynamics of populations of mice which centers about Elton's laboratory at Oxford.

The remaining 60 per cent. of the book is devoted to some of the animal populations of more northern lands. There is a condensed account of the much-discussed lemming cycles in Scandinavia and finally the last half of the book is taken up with wild-life cycles in northern Labrador. Here, attention often shifts for chapters at a time away from the mouse-like rodents to arctic and colored foxes and other aspects of the population problem. Also the tempo of the book changes; the treatment is more detailed and frequently tedious for the general reader. These slower moving chapters become important source mate-

[1] *Voles, Mice and Lemmings; Problems in Population Dynamics.* Charles Elton. Illustrated. 496 pp. June, 1942. $10.00. Oxford University Press.

rial for the special student. The data center about fur returns and the reports of fur traders. The pitfalls inherent in such sources are outlined with care, after which an attempt is made to make the data carry a full load of interpretative analysis.

The discussion of cycles of abundance lies near the heart of the whole book. One notable feature is Elton's rejection of the 11+ year sun-spot cycle in connection with cycles of abundance of certain animals. A few quotations will give needed perspective. In 1924 (*Brit. Jour. Exp. Biol.*, Vol. II, p. 133) Elton said: "I shall attempt to show that the 10 to 11-year period of the rabbit may be due primarily to the 11-year period in the sun." And later in the same article (pp. 138–139), "If we allow for the irregularity in 1905, the rabbit period agrees very well with that of the sun-spots: *i.e.*, omitting the one in 1905, the average period for rabbits between 1845 and 1914 is 11.5. But the 1914 one should have been in 1912, and this brings the average to 11.1, which is about that of the sun-spots (=11.2)."

In his excellent small text-book, "Animal Ecology" (1927, p. 130), Elton continued: "The chief cause of fluctuations in animal numbers is the instability of the environment. The climate of most countries is always varying, in some cases regularly—as in the case of the eleven-year cycles in temperature and the frequency of tropical cyclones associated with the sun-spot cycle." In the present book (p. 160), the conclusion is: "I do not intend to go very deeply here into this theory about the sun-spots. There can be little doubt that it is wrong. . . . The chief point is that the biological rhythm is slightly shorter than that of the sun-spots, and long series of fur returns shows that the two cycles pass right out of phase. . . . Incidentally, it is a pity that several text book writers have quoted as a fact the sun-spot explanation of the Canadian forest cycle, which was explicitly put forward as a hypothesis to be tested by further research."

Elton still retains the possibility of an extra-mundane origin of these cycles of abundance. With regard to the lemming fluctuations in Scandinavia, whose suggested periodicity is three to four years, he concludes (p. 230): "So we are left, as with the British cycle, with a good many hints of some great cosmic oscillation, expressing itself in periodic upheavals in the biotic community, but we still lack the full key to the problem." One good reason for this lack is the absence of any well-established physical cycle with a similar periodicity.

The basic tables are arranged throughout the book to bring out evidence of periodic tendencies in population density. The text frequently summarizes the intervals between peaks of abundance and gives a mean value which is apparently taken seriously. The average length of the lemming-fox cycle in Northern Labrador is repeatedly given as approximating four years. One listing taken at random, that for colored fox skins traded in Ungava (p. 423), has intervals of "3, 3, 8, 3, 3, 2, 6, 4 or 5, 5 or 4, 3, 4, and 5: that is 12 cycles in 50 years, a crude average of 4.17. If we average all but the long cycle of eight years, the result is 3.8 or exactly the same as for the arctic fox." One may be pardoned, perhaps, for regarding such averages with skepticism particularly when we read in another connection (p. 325): "If the peak years are accepted to be 1921, 1925, 1927, 1931 and 1934 (the last is substantially confirmed by reports of a falling-off in 1935, though I have not the actual figure), they give a period sequence of 4, 2, 4, 3. If 1926 was not really a minimum, the sequence is 4, 6, 3. Either involves a reversal of phase in the four-year cycle such as happened in the nineties." The previous "reversal

of phase'' is described on page 270 where the observed and hypothetical four-year periodicities came into complete opposition.

As an interested onlooker of the study of population fluctuations in nature, with the background of having read recently rather extensively concerning climatic and population cycles, it seems to me to be much more helpful at present to accept the variations in length of these swings in abundance as being an inherent, integral part of the phenomenon. They always occur where the records run for many years and are usually observed in shorter series. Such irregularities are common in biological phenomena that are essentially more simple than are fluctuations of population densities in nature. The more I consider the situation, at second or third hand to be sure, the more defensible appears the suggestion that these recurring, sometimes dramatic, swings in population density are an expression primarily of interlocking factors inherent in the loosely integrated population. This view does not imply an absence of effect by the physical environment, which, for that matter, may also show shifts in the length of a given cycle, but it does suggest that the physical environment plays a more remote subsidiary role. If this suggestion is accepted as a working hypothesis, the implication is that the lack of a close balance in population numbers, year after year, results primarily from the biotic relations within the population in question and between it and other populations of plants and animals with which it is associated, rather than the oscillations being the result of some imposed cosmic periodicity. If we can accept the irregularities as an inherent part of the phenomena at hand, rather than struggling, consciously or unconsciously, to fit the data into a periodicity of given average length, I believe we will be better prepared to make needed advances in the solution of these complex, but highly important population problems.

The wealth of tabular material allows the reader of the current volume a much better chance of evaluating the reality of correlations between cycles of abundance of different species than is possible when the basic data are given solely, or mainly, in small-scale graphs. The lack of statistical tests of the validity of proposed interpretations and correlations is a marked technical weakness despite the fact that many of the suggested correlations are shown in tabular form such that it is easy to make an informal estimate of their reality.

It never seems quite fair for a reviewer to mention small errors of proofreading or otherwise, unless they are characteristic of the book. The present volume is remarkably free from such, hence the statement (p. 110) that Mount Rainier is in New York State is all the more surprising. North Americans know better and, I presume, no one else cares.

Elton's stimulating and valuable study grew out of the work, ideas and records of the Oxford Bureau of Animal Populations, of which he is the capable moving spirit. Their archives contain abstracts of obscure and fugitive writings and they have access to the extensive records of the fur trading companies and missions of the Canadian Northeast. The important, pioneering efforts of this organization are supported in part by Oxford University. Initial support from the New York Zoological Society is acknowledged. The financial aid has come mainly from British sources including the Royal Society, the Forestry Commission and the Agricultural Research Council.

Despite the emphasis on cycles of abundance, the recurring theme of the book is the lack of information about

even the more elementary aspects of many of these problems. As Elton emphasizes, we do not know, for example, the actual population densities with which we have to deal. We do not know whether variation in rate of reproduction or in mortality plays the more important role in producing fluctuations in numbers. We do know that both may be important but we do not know the extent to which the two are interlocked. The need for the presence of trained ecologists on the spot in the rodent-ridden fields and pastures of France and in the northern fur country is emphasized. The need for the development of adequate knowledge of rodent diseases in nature and their correlation with human health problems is stressed. The number of furs that can be safely taken over a period of years, the amount of emigration and the distances covered, the interlocking relations between the size of the populations of lemmings, diseases of foxes and of load-pulling dogs, these are only a few of the points concerning which ignorance is stressed. "All [such] population research is tedious and requires a five- or ten-year run if new techniques are to be evolved that will produce safe results." Many of the problems can be brought into the laboratory for experimental analysis under controlled conditions; others can be successfully attacked only in the field.

Finally, "it is to be hoped that the reader of this book will by now have seen that we stand on the near shore of an ocean larger than any that Columbus explored, in which we can at present discern only a few islands rising out of the mist. Let us hope that wise governments [and other institutions] will train navigators and equip them to explore more closely the Islands of Vole, Mouse and Lemming and that they will do so not only in order to round Cape Fox and cross Dog Deep, but with some idea of understanding, not for power alone, but on account of its own wildness and interest and beauty, the unstable fabric of the living cosmos."

TRAVEL TO THE NATIONAL PARK AREAS

ALTHOUGH the National Park Service is accustomed to reporting large annual increases in travel, this year's figures show a decrease of 30 per cent. from last year, and travel for the month of June, 1942, as compared to June, 1941, showed a 50 per cent. decrease. However, an impressive total of approximately 16,030,000 visitors, including an estimated 650,000 members of the armed forces, visited the Federal park areas between July 1, 1941, and June 30, 1942, approximately 4,000,000 of whom were visitors after December, 1941. The rubber and gasoline shortages, the need of conserving transportation equipment for use by the military and war agencies and the limited vacations of workers in war industries made advisable the curtailment of promotion of park attendance not only by the National Park Service but also to a large extent by the park operators. Two meetings of representatives of the park operators were held with the director after the declaration of war. In so far as was consistent with the changing war program and the position taken by higher authority, it was agreed that the parks would remain open and public-service facilities would be made available to provide accommodations for the people who are able to visit the parks. Special reduced rates were continued in effect for members of the armed forces. The park superintendents were delegated authority to adjust rates and services to meet the rapidly changing war conditions.—*From the "Annual Report of the Director" of the United States National Park Service.*

BOOKS ON SCIENCE

GROWTH AND PATTERN IN THE BIOLOGICAL WORLD[1]

AGAINST parochialism in science, especially in biology, there is no more potent antidote than D'Arcy Thompson's, "On Growth and Form." In the second edition of this atmospheric masterpiece, physicists and mathematicians will again find their labors bearing new fruits in novel settings, while engineers, if not depressed by the anticipations of dinosaurs, will detect in the vertebrate skeleton either the realization of their best structural ideas or else suggestions for new ones. However, for biologists by and large "On Growth and Form," though disconcerting, should be intensely luminous and required reading. Even a layman dipping here and there is certain to find some weighty or delightful titbit in his net.

Within the wide realm over which Professor Thompson has presided for over twenty-five years, little has happened domestically to change the original structure and tactics of his book. For reasons usually unsuspected, morphologists have sterilized the analysis of finished form and are now concerned with incipient form or else browse in adjoining and temporarily more succulent pastures. While the progress made by morphological outpatients is reflected in the revisions, most of the amendments derive from the senior sciences or represent increments of learning and insight that have come to Sir D'Arcy from almost everywhere since 1917. In the aggregate these additions are massive. The list of topics, objects and personal names in the index has grown from roughly 1,464 to about 2,236. The footnotes alone would now make a unique compendium. Here ranging over the ages are quotations and references often unusual and usually neglected; numerous fragments of history otherwise inaccessible and sometimes shameful; excellent shop-talk and piquant asides. The absence of visible seams between the innovations and the old fabric is the more remarkable because of Sir D'Arcy's way of saying things. His style, still hampered only by the inhibitions of sound scholarship, flows easily and crystalline among biological, physical and mathematical rocks, yet modulated at will also expresses the intellectual serenity of a philosopher, the heat in the heart of a lover of knowledge and the deep feeling of a connoisseur of the good life. For sheer beauty it is difficult to match the Epilog with its significant and moving final tribute to the naturalist, Henri Fabre.

But what is the book about? Having lost none of its original virtues there is also no abatement in what many consider earmarks of original sin. Among living things form is a fact no less striking than among crystals. In both cases the materials out of which form fashions itself and the spaces within which the fashioning occurs have intrinsic properties antecedent to the form. These properties determine what form we shall finally see. But every living thing begins its independent existence with an endowment of ancestral genes. These also determine what the form shall be. This distinction between the properties which an organism has because it is part of this world at all and those which it has because its race has managed to survive, is not always easy to make but always easier to deny the closer a critic approaches the absolute zero of insight into physical science.

Sir D'Arcy Thompson can hardly be accused of being unbiological. Long intimate with living things, his constant reference to the organism as an entirety,

[1] *On Growth and Form.* D'Arcy Wentworth Thompson. Illustrated. 1116 pp. $12.50. August, 1942. Cambridge: At the University Press; New York: The Macmillan Company.

his concern with relevant detail, and his insistence that intrinsic properties of component materials express themselves only under the restraints and constraints imposed by the organism all confirm his biological orthodoxy. What then is so heterodox?

Biologists adept at witchcraft of their own are often curiously subdued in the presence of real abstractions. Having separated the physically intrinsic from the physically but not biologically extrinsic, Sir D'Arcy reduces organic form to a diagram illustrating the combined play and interplay of all the forces operating at both physical and biological levels. Identical forms, whatever their size and no matter what the immediate circumstances of their origin, yield identical force diagrams. The consequences are often startling. The pattern of a chambered nautilus and the shell of a one-celled foraminiferan are both symptoms of underlying systems of energy whose visible expression in either case is the "Archimedean Spiral." The shape of a jellyfish and the head of a hydroid polyp are equilibrium figures akin to a permanent splash while the tetrahedral angle of spicules in sponges, corals and sea-cucumbers points to another type of physical uniformity in the generating force-field. Rarely as yet can the forces themselves be identified. Everything depends on the order of magnitude.

Sir D'Arcy devotes much of his space to the importance of mere size and exhibits the incongruities that follow when conclusions based on one order are transferred without change to a totally different order of magnitude. Thus when cilia become small whips their activity and even location tell little about the molecular forces that are effective and maintain in the one case an unstable and in the other a stable equilibrium. Once the far-reaching implications of this point are recognized in gross morphology, another mythological branch will crash at the foot of the phylogenetic tree.

With the recognition of size per se goes the analysis of changes in size. Though always absolute, their chief importance becomes apparent when they are relative. Every organism begins at the microscopic level; many become macroscopic, and practically all undergo complication through differences in local growth. Both absolute and relative growth are discussed in the chapter on growth rates, but with little indication that the "Thompsonian Transformations" of 1917 were the forerunners, and still remain, the hitch of heterogony. In his chapter on the Theory of Transformations Sir D'Arcy changes the relative values of units along conventional Cartesian axes and puts the methods of the cartoonist to scientific use. But amazing as it is, the transformation of a porcupine fish into a sunfish results in something more than fun. For "if in the evolution of a fish for instance, it be the case that its several and constituent parts, head, body and tail or this fin and that represent so many independent variants, then our coordinate system will at once become too complex to be intelligible . . . ". Indeed with anarchy in a normal organism so improbable Sir D'Arcy's method is sufficiently sensitive to detect whether a given bone or skull in a paleontological series of horses or men belongs to the stem we happen to be tracing or to some related side-line. Yet until some young paleontologist is prepared to bestow immortality on his critics, these transformations are likely to remain a red rag in the paleontological arena.

If the morphologist of the future is to go on at any of the levels where "Growth and Form" leaves off, he must undergo far more rigorous discipline in physics, chemistry and mathematics. Ultimately, Sir D'Arcy considers the mathematical requirement will exceed the competence of biologists. He envisages a day when all that is really important in biology must become the property of the most highly skilled of

physicists and mathematicians. Should this biological gloom materialize, physicists and mathematicians would need to become biologists and instead of dictating the terms under which they will work, must be prepared to accept dictation from the organism. A more likely alternative would seem to be team-work among scientists of all types. In the meantime what one biologist has accomplished single-handed should be a beacon light for all. Bring the distant future what it may, biologists working at the higher levels can best consolidate their gains and facilitate a real articulation of gross morphology with the newer results pouring in from the lower biological and molecular levels if they will make here and now wholehearted and concerted efforts to follow the trail blazed by D'Arcy Thompson's "On Growth and Form."

OTTO GLASER

INTERPRETATION OF SCENERY[1]

IN considering "Geomorphology" by von Engeln, the present reviewer is asking the question: to what extent is the layman able to use profitably an advanced college textbook in such a field of common interest as the interpretation of scenery? Regardless of the virtues of the book as a classroom guide, regardless of its richness of illustration and bibliography, will it answer adequately the kind of questions which may be asked by the earth-conscious traveler who is untrained in geology and geography? A biology teacher or a chemical engineer who enjoys travel may wonder how "things got that way" and hope for help from such a book. What, for instance and at random, about geysers in the Yellowstone, or what about the Devil's Tower, or, after a North Cape cruise, how about fiords? Obviously the book was not written for this purpose but, considered as a "Book on Science for Laymen," it is being evaluated with that possible virtue in mind.

Let us investigate the three topics mentioned above. A good impression comes from the index. It seems to be adequate, for all three items are included. Looking up geysers, we meet a little disappointment. Geysers are said to be not really pertinent to geomorphology. We do get some helpful information about how they obtain their heat though there is nothing to be found about the mechanism of intermittent eruption.

Devil's Tower (p. 307) appears to be all that remains of a dome-like igneous intrusion called a laccolith. There is a cross-section of a laccolith on the opposite page so we can discover what the term means, and a good picture of Devil's Tower on the next page so we can put diagram and reality together. However, we turn to the second reference (p. 609) and find that Devil's Tower is a volcanic neck, though there may be some dispute about it. We turn back a page to find out what a volcanic neck is and run into terms like "barrancas" and "planizes." Barrancas result when "originally numerous, subequal, consequent-stream furrows on the sides of a cone are in time replaced by a comparatively few deep and wide valleys." Eventually we find that a volcanic neck is one of the forms of "the inversion of relief that gives extraordinary prominence to a particular type of monadnock." At this point, as laymen, we are likely to turn back to the remnant-laccolith idea.

Now "fiord" (p. 468). Here we find that "sea-invaded basins, which commonly extend inland between nearly vertical walls, are *fiords.*" They were probably occupied in glacial times by tidal glaciers which ended seaward in great ice cliffs. So far, very good; then we try to follow the argument and we come on to "The depth of water in the part now evacuated is so great that the

[1] *Geomorphology. Systematic and Regional.* O. D. von Engeln. Illustrated. xxiv + 655 pp. $4.50. 1942. Macmillan Company.

above-water ice cliff would have been much higher than it was if the ice had been buoyed up at its terminus."

Although the topics were selected at random examples of the same kind might be multiplied. This reviewer's conclusion is that unless the layman is prepared to absorb a profuse terminology and unravel involved English he will not find the book helpful as a reference for the interpretation of scenery. At the present time it may be fortunate that many foreign terms like "wadi" are included. Ordinarily such nomenclature is of value only to the advanced student and professional.

If the layman is concerned with understanding the current state of one aspect of the earth sciences the volume can be said to reflect well the minds and attitudes of the more progressive geomorphologists. The presentation of the Penckian doctrines along with the traditional American, and the frequent reference to dissenting opinion are indicative of a broad scientific philosophy. And certainly no one can read a book and believe that any phase of the subject matter is static. Geomorphology, as with all branches of knowledge, is "unfinished business."

A. C. SWINNERTON

A STUDY OF BIRD PSYCHOLOGY[1]

THE work of the last decade or two on various aspects of bird behavior has changed our concepts of the "how" and "why" behind the activities of birds far more than has the descriptive or faunal work of the same period altered our ideas of bird classification and distributional history. The present book, which includes far more than its main title implies, is a welcome summary and critical digest of a great mass of recent work on birds in practically all parts of the world. The bibliography contains approximately 600 entries, and while some important behavioristic studies are omitted, the bulk of the more significant ones are included. While the vast literary material here assembled is introduced as needed into the text, the reader does not get the feeling of going through a mere series of excerpts and quotations. The author presents his own data and interpretations based on his personal experience plus the literature, which he calls in as evidence when needed.

Beginning with an account of the ceremonial activities of the gannet, Armstrong treats of such topics as the development of nest-building, courtship feeding (with amusing human parallels), ceremonial gaping, the "disablement reactions" involving injury—feigning and trance-like states and activities that reveal emotional states, and then goes on to discuss ceremonial behavior, both mutual and reciprocal, semi-solitary and social. This leads to a chapter on "The Dances of Birds and Men" followed by discussions of arena displays, the sex-ratio, territory, song and the display itself.

While supporting in large measure the interpretive suggestions and theories of Lorenz, the author is much impressed by Eliot Howard's semi-mystical, semi-philosophical analysis of the avian mind. Armstrong ends his brief account of the significance of display by reminding us that the bird's world is like a dynamic system of ever-changing relationships. "In the words of Hippocrates: 'Everything is in whole—part relationship, and, part by part, the parts in each part operate according to their function.' "

The book is not intended as easy reading, but is actually not only very readable, but by virtue of its condensed richness of data, an "easy-reading" of a large and scattered literature. Three indices, one to the species mentioned, one

[1] *Bird Display. An Introduction to the Study of Bird Psychology.* E. A. Armstrong. Illustrated. xvi + 381 pp. $5.50. December, 1942. The University Press, Cambridge, England (Macmillan).

to the topics, and one to the authors quoted, make the contents of this important book readily available to the interested reader.

HERBERT FRIEDMANN

A TRIP AMONG THE ISLANDS OF THE SOUTH PACIFIC[1]

A VOYAGE in a sixty-foot schooner through the Panama Canal and across the Pacific, with stops at the Galapagos, Marquesas, Tahiti, Samoa and Fiji, to Ontong Java, and then on to New Guinea, is in itself quite an excursion, but to the author of this book, merely the beginning.

During the voyage, observations were made of migratory birds and ocean life, but in New Guinea the real work of collecting ornithological specimens and observing bird life was begun. Fortunately, the Dutch Administrator, Mr. van der Goot, was about to make a patrol into the interior, and in his company the author made his first journey into the bush. Government rest houses, where they existed, were comfortable, but usually home was made in rickety houses in native villages where society consisted partly of rajahs, mostly of cannibals. In the mountains, sleeping in wool-lined bags, life was different from on the coast, where a rainproof cloth over one causes as great humidity inside as out. Van der Goot adapted himself to weather conditions by strolling through the rain smoking his pipe with the bowl upside down, and turning it right side up when the rain stopped.

[1] *Trail of the Money Bird.* Dillon Ripley. Illustrated. xii + 306 pp. $3.50. 1942. Harper and Brothers.

The author observed in New Guinea dances of birds of paradise, and the activities of the rare, New Guinea bower-bird. His native assistants collected and brought to him, among other things, small rails, together with the little houses bower-birds make of leaves to rest in during the night. Large collections were made, and many unusual and new notes on birds were obtained.

In addition to his ornithological work, Ripley experiences the usual hardships of travelers in the South Seas—bad weather, late Government parties, foot ulcers, leeches, and cold fried eggs for lunch.

After the big adventure of crossing the Pacific in a small boat, and a bigger one in New Guinea in territory new to collectors, there followed the voyage home, first in one of the comfortable Dutch passenger boats to Singapore, and then on a freighter, a forty-nine-day trip around the Cape of Good Hope, to Boston. None of the big steamers would take his cargo of eighty-seven live birds in forty-two cages.

Three adventure trips, all in one book, narrated in pleasant manner touched with humor, make this good reading on subjects of interest to everyone—the South Sea islands; natives, wild and tame; and bird life. The author draws a picture of a region that a few years ago was a collector's paradise, but even then conversations with settlers and Government officials regarding Japanese already there and others expected to come sounded an ominous note.

A series of interesting pictures adds to the enjoyment of the reader.

W. M. MANN

THE PROGRESS OF SCIENCE

THE NEW PRESIDENT OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THOSE of us who belong to the large but favored group of Isaiah Bowman's old friends need a sharp reminder that "everybody" doesn't know him! There are, strange as it seems, thousands of fellows and members of the association who have yet to learn what manner of individual has just become the ninety-third president. Their curiosity, moreover, probably centers around questions of personality and traits rather than the impressive list of honors and responsibilities tersely set down in "American Men of Science," "Who's Who in America" and similar works of reference.

For the benefit of all such, let it first be noted that President Bowman is a very young man. The good die young, according to cynics, but the true explanation is not that they die *when* they are young but that they are young when they die. The inexorable record tells us that Bowman was born on the day after Christmas, 1878. Yet the characterization of a reporter who interviewed him in 1935, at the time he assumed the presidency of The Johns Hopkins University, applies with equal force to-day. It was: "Dr. Bowman is 57, looks 47, acts 37." Any one, indeed, who fails to deduct a round score of years from the new president's theoretical or chronological blood pressure and arterial elasticity will be bound to suffer an initial disadvantage.

It reveals no secret to state that Dr. Bowman has long been numbered among the annual candidates for the presidency of the association. One admirer, sending a letter of congratulation only last month, also offered to explain his election. "I have been voting for you for the last decade," he wrote, "and the Council has only just reached the point of counting all my ballots!"

Bowman is, and always has been, a geographer. No dictionary definition, however, encompasses the scope to which he has applied his chosen discipline. He has made his discoveries and wisdom bear not only upon the external world, but also with particular aptness upon sociology, history, government, international relations, the conservation of natural resources, and education (including that of his own children no less than of institutions). In short, he reveals "the pervading soul of the geographer that sees the basic bearing of the frame of the earth and the physical as well as social ties of its inhabitants."

Bowman received his bachelor's degree from Harvard in 1905. He still looked like a freshman, but he was considerably older than the average for his class because he had already completed the course in the State Normal College at Ypsilanti, Michigan. He then transferred to Yale, taking his doctorate in 1908 and remaining as instructor and assistant professor in the department of geography until 1915. In 1909, he married Miss Cora Olive Goldthwait, of Lynn, Massachusetts. Their two sons were born during the period of residence at New Haven and a daughter was added to the family shortly afterwards.

While at Yale, Bowman participated, either as staff geographer or as leader, in the several South American expeditions that opened opportunity to his penetrating insight and interpretive faculties, and led to the publication of one of his most delightful books, "The Andes of Southern Peru," and, later, to "Desert Trails of Atacama."

In 1915, he accepted the post of director of the American Geographical Society, New York City, after obtaining from the governing council assurances

DR. ISAIAH BOWMAN

that gave him a free hand for the productive developments of the next twenty years. The *Bulletin* of this oldest of American geographical organizations was replaced by the scholarly and more inclusive *Geographical Review*, and the society's headquarters rapidly became the center of cooperative work in geographic science, including cartography and the building up of a great library, which has won it a unique position as an essential adjunct, for example, to both peace-time and war-time activities of the United States Government.

In 1920, under Bowman's leadership, the society began the greatest single project ever undertaken by a geographic institution, namely, the preparation of a map of Latin America in conformity with the standards of the "Millionth-Map of the World" recommended by one of the International Geographical Congresses. This undertaking, now at the verge of fulfilment with all but three of the 107 sheets already issued, marks a new peak in excellence for the whole history of New World map-making.

As director of the American Geographical Society, Bowman first came conspicuously into the public eye by serving as an authoritative intermediary between geographic exploration and a general understanding thereof. No man has been more often or more properly sought by the press in connection with geographic news. His intimate relationship with its sources throughout the period of his directorship is indicated by the society's publications on the problems of the polar regions, its charts of the Arctic and Antarctic, and the practical aid it has given to Stefansson, Wilkins, Byrd, Ellsworth, Mawson and the Norwegian investigators of the Far South.

Nor was this advance on the physical frontiers sufficient. Opportunity for larger service in the cause of national welfare likewise appeared. In 1918, the building, staff and collections of the society were put at the disposal of the government for "The Inquiry" to prepare for peace, and Dr. Bowman himself acted as chief territorial adviser to the conference in Paris. No book has brought the society and the author more honor than "The New World," an outcome of these experiences in international affairs.

Bowman's influence stems, of course, not merely from his learning and character but equally from his power of concentration, his quick wit, and the clarity and directness of his speech. He is invariably "loaded for bear" when he opens his mouth, a fact that makes him a forceful protagonist and a dangerous adversary. The latter rôle is well illustrated by his routing of a cross-examining attorney in the famous Red River suit, relating to the boundary between Texas and Oklahoma, in which Bowman was engaged as physiographic expert to testify before a commissioner of the United States Supreme Court.

After drawing from Bowman a prediction as to a future position of the shifting channel of the Red River, the attorney seemingly lured the witness into the fatal commitment that he was quite willing to "prophesy." Somewhat to his surprise, the victim showed no hesitancy in accepting the bait.

"May I ask, then," continued the sardonic lawyer, "whether you regard yourself as a major, or merely a minor, prophet?"

"I am *called* a major prophet," responded Bowman.

His would-be tormenter paused, surveyed the court, and prepared for the kill. But his next question, demanding an explanation as to why an alleged man of science was willing to pose as a prophet, brought forth the riposte that devastated his whole attack and threw the court into a titter. It was only this: "I am called a major prophet, because my name is Isaiah."

We may skip, as information readily accessible elsewhere, the up-to-the-minute catalogue of Dr. Bowman's dozen or more books, six medals, thirteen honorary degrees, nine honorary fellowships in geographic societies, etc. Of his specific accomplishments at Hopkins, the writer is hardly qualified to speak. Neither is he able to distinguish between the president's personal share and that of his inspired colleagues with respect to notable and progressive changes. It is enough to say that wherever Bowman is, nothing stands still. The scholarship of Hopkins has won new laurels under his administration; its financial strength has measurably gained; it has become the first great university to eliminate gate receipts in connection with all athletic contests!

Our summary may be concluded somewhat randomly with a transliteration of a few of President Bowman's vigorous spoken sentiments applicable to questions of national and world-wide interest during the past several years.

Conservation: Americans have been willing to scalp their land and to leave it a red horror.—The waste of running water, and attendant evils, have done more damage to the United States than all its wars.—Man, so often extolled as a builder and beneficent modifier, has been equally a waster and disorganizer of the forces of nature.—Facts more valuable than all the gold of the Klondike lie buried in the climatological records at Washington.

Geography: The American frontier is gone, but the world, including our own country, is still filled with pioneer zones.—The "frozen north" has retreated northward faster than our school books have been revised.

Education: The fact that you are a university graduate may lull you into a false sense of intellectual attainment before you have really begun your life.—There is constant need of scholarship to effect a reconciliation between a society that molds and restricts and the individualism out of which the forces of society have so largely sprung.—Keep a healthy distrust of "common sense," such as once told men the world was flat.—Neither scientist nor government can work on a hunch.

Freedom: Freedom to think, to discover and to report is more important than either government or society itself, for it was out of that freedom, or its winning, that there came ultimately the builders of our civilization.—Beware the false design of citizenship which asserts, "I am a child of the government and heir of my neighbors' industry and prudence."

ROBERT CUSHMAN MURPHY

ANNUAL MEETING OF THE NATIONAL ACADEMY OF SCIENCES

THE eightieth annual meeting of the National Academy of Sciences was held on April 26 and 27, 1943, at the Academy building in Washington; it was attended by 114 members. No scientific papers were read at the meetings; the greater part of the sessions the first day was devoted to general statements of the various investigations undertaken by the Academy at the request of the government. President Jewett opened the discussion with a paper on the "National Academy of Sciences and Its Part in the War—the Academy in Relation to the Government," in which he emphasized the responsibility of the Academy toward the government in the field of science and its applications. Descriptions of various phases of this responsibility and of the steps that are being taken to meet it were given in the following papers:

VANNEVAR BUSH.—The Office of Scientific Research and Development and its relation to the Academy in the war. JAMES B. CONANT.—The National Defense Research Committee in its relation to the Academy during the war. A. N.

RICHARDS.—The National Academy of Sciences and the Committee on Medical Research of the Office of Scientific Research and Development. ROSS G. HARRISON.—The National Research Council and the war effort. CLYDE WILLIAMS (by invitation).—Essential metals and minerals for war purposes (informal discussion by Drs. C. K. Leith and Zay Jeffries). W. F. DURAND.—Application of engineering science in war. LEWIS H. WEED (by invitation).—The role of medicine in the present war. LEONARD CARMICHAEL (by invitation).—Psychology and the war. FRANK G. BOUDREAU (by invitation).—Food and nutrition in war and peace. Program of the Food and Nutrition Board.

Five medals, awarded by the Academy, were presented at the annual dinner on Monday evening, April 26, 1943:

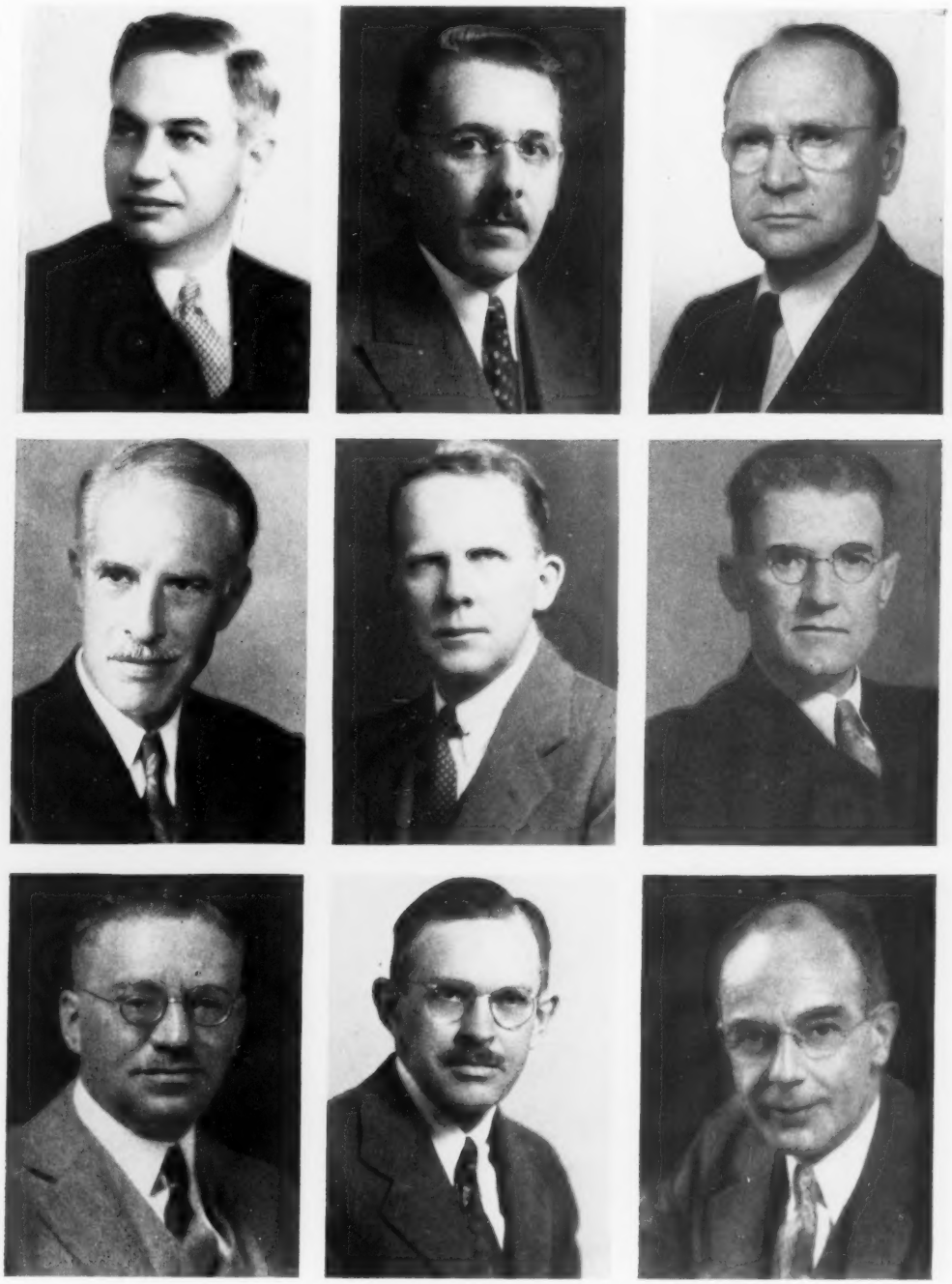
Left to right: Dr. A. Adrian Albert, professor of mathematics, The University of Chicago; Dr. C. G. Rossby, professor of meteorology, The University of Chicago; Dr. J. W. Beams, professor of physics, University of Virginia.

The Henry Draper Gold Medal, awarded to Dr. Ira Sprague Bowen, of California Institute of Technology, Pasadena, California, "in recognition of his contributions to astronomical physics; more especially his researches on the spectra and chemical composition of the gaseous nebulae." The presentation address was made by Dr. S. A. Mitchell, of the Leander McCormick Observatory.

The Alexander Agassiz Gold Medal and honorarium of $300, awarded to Dr. Columbus O'Donnell Iselin II "for his studies of the gulf stream system, for his leadership in the development of a general program of the physical oceanography of the North Atlantic, and for his distinguished direction of the activities of the Woods Hole Oceanographic Institution both in peace and in time of war." The medalist was presented by Dr. Thomas Barbour, of the Museum of Comparative Zoology, Cambridge, Massachusetts.

The Daniel Giraud Elliot Medal and honorarium of $200, for the year 1935, awarded to Dr. Edwin H. Colbert, of the American Museum of Natural History, "in recognition of the high merits of the paper entitled, 'Siwalik Mammals in the American Museum of Natural History' published in the Transactions of the American Philosophical Society in 1935." The medalist was presented by Dr. W. K. Gregory, of the American Museum of Natural History in New York City.

The Daniel Giraud Elliot Medal and honoramium of $200 for the year 1936, awarded to Dr. Robert Cushman Murphy, of the American Museum of Natural History, "in recognition of the high merits of his work on 'Oceanic Birds of South America' published in two volumes in 1936." The presentation speech



TOP: *left to right:* Dr. Lee A. DuBridge, professor of physics, University of Rochester; Dr. Paul D. Foote, vice president, Gulf Research and Development Company; Dr. V. K. Zworykin, director, Electronic Research Laboratory, RCA Manufacturing Company. MIDDLE: L. H. Adams, director, Geophysical Laboratory, Carnegie Institution of Washington; Dr. L. P. Hammett, professor of chemistry, Columbia University; Dr. Walter P. Kelley, professor of agricultural chemistry, University of California, Citrus Experiment Station. BOTTOM: Dr. L. Michaelis, member, Rockefeller Institute for Medical Research; Dr. A. F. Buddington, professor of geology, Princeton University; Dr. H. B. Vickery, biochemist, Connecticut Agricultural Experiment Station.

TOP: *left to right:* Dr. C. V. Taylor, Herzstein professor of biology, Stanford University; Dr. W. H. Chandler, professor of pomology, University of California at Los Angeles; Dr. J. N. Couch, professor of botany, University of North Carolina. MIDDLE: Dr. Leonard Carmichael, president of Tufts College; Dr. Calvin P. Stone, professor of psychology, Stanford University; Dr. Wallace O. Fenn, professor of physiology, University of Rochester. BOTTOM: Dr. Warfield T. Longcope, professor of medicine, Johns Hopkins University School of Medicine; Dr. E. K. Marshall, Jr., professor of pharmacology and experimental therapeutics, Johns Hopkins University School of Medicine; Dr. O. H. Robertson, professor of medicine, The University of Chicago.

was made by Dr. Ross G. Harrison, of Yale University.

The John J. Carty Medal and award for the Advancement of Science, for which the honorarium is $4,000, awarded to Dr. Edwin Grant Conklin, of Princeton University. The citation read: "Zoologist, Cytologist, and Embryologist; Philosopher, Teacher, and Scientist; Student of life and of growth from lowliest beginnings to highest consummation." The medalist was presented by Dr. O. E. Buckley, of the Bell Telephone Laboratories. In accepting the honor Dr. Conklin expressed his pleasure and appreciation of the award and his surprise that he had been selected for it. He recalled his long friendship with General Carty, in whose honor the John J. Carty fund was established, and expressed great satisfaction in being thus associated with one whom he had greatly admired and respected.

At the business meeting held on Tuesday, April 27, the following officers and foreign associates were elected:

President—Frank B. Jewett, Bell Telephone Laboratories; reelected for a term of four years.

Home Secretary—F. E. Wright, Carnegie Institution of Washington; reelected for a term of four years.

Members of the Council (terms of three years).—W. Mansfield Clark, Johns Hopkins Medical School (reelected); Walter R. Miles, Yale University School of Medicine.

Foreign Associates.—Alfonso Caso, archeologist, Instutio Nacional de Antropologia e Historia, Mexico. Harold Spencer Jones, astronomer, Royal Observatory, Greenwich. Richard Vynne Southwell, engineer, Brasenose College, Oxford University. Charles Edward Spearman, psychologist, University of London. Sir D'Arcy Wentworth Thompson, zoologist, University of St. Andrews. Hendrik Johannes van Der Bijl, engineer, University of Pretoria, Pretoria, Union of South Africa.

TOP: *left to right:* Dr. W. Albert Noyes, Jr., professor of physical chemistry, University of Rochester; Th. Dobzhansky, professor of genetics, Columbia University; L. C. Dunn, professor of zoology, Columbia University.

Twenty-six scientists were elected members of the Academy, whose portraits, with the exception of those of Dr. E. J. Cohn, professor of biochemistry at Harvard Medical School, and Dr. William V. Houston, professor of physics at California Institute of Technology, appear on these pages. The present membership of the Academy is 345, with a membership limit of 450; the number of foreign associates is thirty-nine with a limit of fifty.

The autumn meeting will be held this year in Washington, at a date to be selected.

F. E. WRIGHT,
Home Secretary

FRANKLIN MEDALISTS FOR 1943

Two eminent American scientists have been chosen to receive the coveted Franklin Medals, which were presented at the annual Medal Day ceremonies at The Franklin Institute, Philadelphia, on April 21.

George Washington Pierce, who formerly held the chairs of Rumford professor of physics and Gordon McKay professor of communication engineering at Harvard University, has been chosen "in recognition of his outstanding inventions, his theoretical and experimental contributions in the field of electric communication, and his inspiring influence as a great teacher."

Professor Pierce is the author of thirty or forty valuable papers in physics and electric communications, and is the author of two standard books, "Principles of Wireless Telegraphy" (1910) and "Electric Oscillations and Electric Waves" (1920).

Following the discovery of the crystal detector, radio made rapid strides. The crystal detector consists of a material, such as carborundum, against which a metallic contact is held under light pressure. This device possesses the property of conducting current better in one direction than in the other, and the detector action is due to this property. Realizing the importance of the discovery, Pierce began a series of systematic investigations to find what other materials possessed the same rectifying properties, and also to discover to what this property is due. As a result of his investigations, Pierce found a number of minerals which could be used as detectors. He applied the cathode-ray oscillograph to the study of the action and found that neither an electrolytic theory nor a thermo-electric theory could explain the rectifying phenomenon. It is noteworthy that additional investigations have failed to provide a satisfactory explanation of the basic rectification phenomenon in crystal detectors.

His interest in the detection of electric oscillations led Pierce to experiment with mercury vapor arcs for this purpose. The outcome of his researches was the mercury vapor detector and amplifier. This tube is equivalent to the "Thyratron," developed later by A. W. Hull, of the General Electric Research Laboratories. The chief difference between Pierce's tube of 1913 and the present day thyratron is the use in the latter of a hot cathode as a source of electrons instead of the mercury tube and "keep-alive" circuit employed by Pierce. However, he employed his tube as an amplifier as well as a detector. In one of his patents he discloses a method of using it in a way which is equivalent to the present use of the mercury tube employed to record variable-density sound-on-film.

During the last World War, Pierce gave his full time services to the United States Navy at the Naval Experimental Station, New London, Conn. Together with other well-known physicists, he was engaged upon diversified research related to the creation of devices for locating submerged submarines. His work touched practically every aspect of the manifold problems arising from this enterprise. His profound knowledge of theoretical and practical physics, and his ability to design workable equipment were a source of constant amazement to his associates. Probably his most important personal contribution to the work was the electrical compensator. This ingenious device was the electrical analogue to Dr. Mason's multiple-unit acoustical listening device, the MV tube.

The electrical compensator contained a multiplicity of electrical lag lines which were invented by Pierce. These were formed of repeated sections, each consisting of a series inductive element and a shunt capacitive in the higher audible or ultra-audible range. He was the first to demonstrate that such lines had the property of retarding electrical

impulses by time intervals which were equal to the square root of the product of inductance and capacitance of the individual sections, and that the correct amount of mutual inductance between adjacent sections was beneficial to the transmission characteristics of the line.

Cady pointed out in 1922 that the piezo-electric effect in quartz crystals could be used to control the frequency of electrical vacuum tube oscillators. By virtue of the extremely low internal viscosity and the small effect of temperature such crystal resonators are extremely stable and permit control of the frequency of oscillators to a few parts in ten millions under proper conditions. Much impressed with Cady's work, Pierce began the study of suitable oscillator circuits for use with quartz crystals. He produced three fundamental types of circuit employing one tube and one set of electrodes on the crystal. Cady had previously employed two tubes and two sets of electrodes, so that Pierce's circuits were a considerable simplification.

This joint invention by Cady and Pierce is one of the most important inventions made in radio during the past twenty years. Because of the necessity of holding frequencies to narrow limits all broadcasting stations are required by law to employ quartz crystal stabilization. Another important use is in electric clocks and in frequency standards. The quartz crystal clock is probably the most accurate time-keeper ever devised.

When a bar of iron or nickel is magnetized it changes shape due to the effect called "magnetostriction." Also, when a bar of iron is deformed it generates a magnetic moment by a converse effect. These two effects may be compared to the direct and converse piezo-electric effects in a quartz crystal, which has just been described. Pierce recognized that the phenomenon of magnetostriction could be used to control the frequency of oscillators by mechanical resonance in the same way as with quartz crystals. Near the frequency of mechanical resonance bars of proper composition exhibit a considerable reaction on the electric impedance of a coil wound around them. Pierce devised a number of oscillator circuits for making use of this property.

THE FRANKLIN MEDAL

Professor Pierce's influence has been impressed widely upon the field of electric communication, for the majority of the men who are engaged upon important work in radio engineering all over the world have studied in his classes. His courses in wireless telegraphy were among the first to be given anywhere,

DR. G. W. PIERCE

and for years were a standard on which other schools based the development of their curricula. Pierce recognized that the art of communication was neither physics nor engineering, but a combination of the two. He always insisted upon a liberal grounding in mathematics and usually left the engineering part to be developed by the student himself as he went along.

The other Franklin Medalist is also a native-born American. Dr. Harold Clayton Urey was born in Walkerton, Indiana. Graduating from the University of Montana with the degree of bachelor of science in zoology, Dr. Urey concentrated on chemistry when he received an appointment in the laboratory of the Barrett Company in Philadelphia. Later he spent a fruitful year in the laboratory of Nils Bohr at Copenhagen. Upon his return to the United States he went to Johns Hopkins University as associate in chemistry, from which he went to Columbia University where he eventually became professor of chemistry.

During the past dozen years, Dr. Urey has written more than sixty papers for technical journals and is co-author with

DR. HAROLD C. UREY

Professor Ruark of the book "Atoms, Molecules, and Quanta." He has been editor of the *Journal of Chemical Physics* since its inception.

Dr. Urey has been the recipient of the Willard Gibbs Medal from the American Chemical Society, the Davy Medal from the Royal Society and the Nobel Prize in Chemistry. The award of the Franklin Medal is in recognition of "his discovery of an isotope of Hydrogen of mass 2, which has resulted in the opening of new fields of knowledge in three of the physical sciences."

The atomic weight of an element is usually found as the result of some chemical procedure in which the mass of a given volume of the unknown element is compared with the mass of the same volume of oxygen, assumed to have an atomic weight of 16.0000. Many millions of atoms of the unknown element, as well as many millions of atoms of oxygen, participate in such an experiment. Unless all the atoms of oxygen have identical mass, and all the atoms of the unknown element also have identical mass, the atomic weight so found represents only the average atomic weight of the group. In the case of hydrogen the atomic weight thus found has the value of 1.00777.

With the discovery of the mass spectrograph by F. W. Aston it became possible to calculate the atomic weight of particles appearing upon a spot on a photographic plate. Particles of different atomic weight were focussed upon different spots on the plate. Aston found by his method that the atomic weight of hydrogen is 1.00778. However, it was later found that normal oxygen is a mixture of 0(16) with small amount of 0(18) and 0(16). Therefore, if we take the atomic weight of 0(16) as 16.0000 it is clear that the atomic weight of oxygen as found by the chemists must be slightly higher than 16.0000 due to the presence of the heavier isotope. Since the atomic weight of hydrogen is established by comparison with that of oxygen, the inference is that the atomic weight of hydrogen should be higher than 1.00777.

Birge and Mentzel pointed out that the higher value for hydrogen might be explained by postulating the existence of one or more heavier isotopes of hydrogen. They estimated that if there existed a single isotope of atomic weight approximately 2, there would be need for only one atom of H(2) to 4500 atoms of H(1) in order to account for the discrepancy. In 1931 it was not possible to detect an isotope of such infrequent occurrence.

At this point Dr. Urey attacked the problem. He realized that, in order to establish the existence of H(2), two things were required: (a) he must find a method of concentrating the heavier isotope in a sample of hydrogen so as to increase the frequency of its occurrence, and (b) he must find a more sensitive method of detecting the presence of the heavier isotopes than that provided by the mass spectrograph.

From the thermodynamic theory he deduced that liquid H(2), deuterium, should have a somewhat higher boiling point than liquid H(1), protium. Hence, he turned to fractional distillation as the means of concentrating deuterium by boiling off the protium. Since it was clear that the difference between the two boiling points must be small, he had to work as closely as possible to the known boiling point of hydrogen. We now know that the boiling point of protium is 20.4° Abs. and the boiling point of deuterium is 23.5° Abs. In one experiment he started with six liters of hydrogen and boiled it away until there was left only one cubic centimeter.

For a more sensitive method of detection Urey turned to the spectroscope. Bohr's theory of the hydrogen spectrum had been successful in deriving a relationship between known physical constants and Rydberg's number, familiar to all spectroscopists. This theory is based upon the assumption that an atom of hydrogen consists of a single proton which remains motionless while an electron revolves about it. In reality, the proton and the electron must both revolve about a common axis which does not pass through the center of the proton, just like the earth and the moon.

If we now postulate the existence of deuterium, Bohr's theory leads us to suppose that a deuterium atom possesses a structure similar to that of a protium atom in having a single orbital electron but different in having a nucleus of about twice the mass. Hence, Rydberg's number for deuterium should be a little larger than that for protium.

In order to make use of a high-powered spectrometer and also to carry out the work of liquefying large quantities of hydrogen, Urey and his assistant, Murphey, went to the Bureau of Standards, and enlisted the aid of Dr. Brickwedde. They set up a spectrometer using a concave diffraction grating of 21-foot focus with a dispersion of 1.3 A per millimeter, and photographed the spectrum obtained from an electric discharge in a tube containing hydrogen. Three samples of this gas were investigated: ordinary hydrogen, hydrogen en-

riched by boiling at atmospheric pressure, and hydrogen enriched by boiling at a temperature just above the triple point.

The first photograph showed the strong H line accompanied by a very faint line on the short wavelength side, which might or might not be a ghost line. The second photograph showed the companion line in the same location but of increased intensity. In the third photograph the intensity of the companion line was much greater, leaving no doubt as to the true nature of this line. The separation was measured as 1.313 A, very close to the calculated value of 1.326 A. Other lines in the spectrum were found to be accompanied by a companion on the short wavelength side.

Since deuterium promised to be such a useful substance, if only it could be obtained more readily, Urey set to work to devise a better method of enrichment than fractional distillation. By the use of fractional electrolysis he was able to obtain a residue containing as high as 90 per cent. heavy atoms.

The discovery of deuterium has proved to be one of fundamental importance in the fields of chemistry, physics, and biology. A new chemistry has been born in which every compound containing hydrogen is found to acquire changed properties when deuterium is substituted for protium. In the field of nuclear physics, deuterium has proved of inestimable value because of its use as a projectile accelerated to terrific speeds in an atom-smashing machine. When the electron has been knocked off an atom of deuterium there remains only the positively charged nucleus, or deuteron, which is twice as heavy as the nucleus of protium, or proton. In the atom smasher the deuterons acquire high speed and comparatively great kinetic energy which enables them to penetrate into the very hearts of much heavier atoms against which they are shot. The result is that these heavier nuclei are frequently smashed to pieces, giving rise to new nuclei, which means that new atoms with new properties have been artificially created, a process of actual artificial transmutation of elements.

The use of deuterium in biological work is interesting if not as important, at present, as in chemistry and physics. Tadpoles are killed when required to live in 92 per cent. heavy water. A mouse which has been deprived of water overnight showed marked signs of intoxication when fed heavy water. The more of it he drank the thirstier he became, so that it is probable that heavy water is not eliminated so readily from the human body as ordinary water. It is suggested that the proportion of heavy water in the body slowly increases, and thus, perhaps, brings on old age.

The contributions of these two distinguished scientists justifies their inclusion in the increasing list of Franklin Medal winners, which already includes such names as Einstein, Curie, Marconi, Planck, Thomson and Rutherford.

HENRY BUTLER ALLEN

A WARTIME CONFERENCE

THE need for the full mobilization of the trained personnel in support of the war effort was the theme of the "National Wartime Conference" held in New York City in May. It was sponsored by the American Association of Scientific Workers, and the United Office and Professional Workers of America, which is a branch of the Congress of Industrial Organizations[1] and twenty-one other organizations.

The general session was followed by

[1] Dr. Kirtley Mather, professor of geology at Harvard University and President of the American Association of Scientific Workers, served as conference chairman. The presiding officers and their panels on science were: Otis W. Caldwell, "Science and Technology"; John P. Peters, "Health and Welfare."

PRINCIPAL SPEAKERS IN THE "SCIENCE PANEL"

LEFT TO RIGHT: SENATOR HARLEY M. KILGORE; FREDERICK L. HOVDE OF THE NATIONAL DEFENSE RESEARCH COUNCIL; DR. THEODOR ROSEBURY, CHAIRMAN OF THE NEW YORK BRANCH OF THE AMERICAN ASSOCIATION OF SCIENTIFIC WORKERS; DR. ALBERT B. NEWMAN, REGIONAL ADVISER OF THE ENGINEERING SCIENCE MANAGEMENT WAR TRAINING; DR. OTIS W. CALDWELL, EMERITUS PROFESSOR OF EDUCATION, TEACHERS COLLEGE, COLUMBIA UNIVERSITY; DR. A. KENNETH GRAHAM OF THE WAR PRODUCTION BOARD; LEWIS A. BERNE, PRESIDENT OF THE FEDERATION OF ARCHITECTS, ENGINEERS, CHEMISTS AND TECHNICIANS OF THE CONGRESS OF INDUSTRIAL ORGANIZATIONS

simultaneous panels on science and technology, health and welfare services, education, white collar fields, and the arts and letters, each of which discussed three themes: the group's contribution to the war and to the peace, obstacles to the fullest participation in the war effort, and suggestions for overcoming them.

The science and technology panel emphasized the need for scientists and for effective organization and integration of scientific work. Mr. Frederick Hovde and Dr. Kenneth Graham described the work done by the Office of Scientific Research and Development and the Office of Production Research and Development of the War Production Board.

Defective allocation of manpower contributes to a growing shortage of trained personnel, Dean Albert B. Newman, of the Engineering School of the City College of New York, emphasized. He warned that the nation faces an acute shortage of adequately trained engineers. He said that the colleges will be able to supply only 10,000 of the 40,000 additional engineers needed in 1943. Industry contributes to this shortage by failing to request deferment for trained men. Financial considerations and general public approval for a college "which goes 100 per cent. military" are moving many college administrators to "dismiss all civilian students and fill up with Army and Navy trainees"; the training given them is inadequate for the demands of industry. Senator Harley M. Kilgore, sponsor of the current "Science Mobilization Bill," expressed the opinion that the "Scientific Roster" had not been used adequately. Dr. Theodor Rosebury pointed to the store of skills of scientific personnel which he thought had not yet been brought into war activity. The same point was stressed by Mr. Berne.

The speakers urged that the cooperation of scientists with other professions and groups be continued; they agreed with Dr. Mather, who stated, "This is the first time that representatives of all the professions have met together to consider their place in the wide perspective of national life. . . . Our common bond is our love of freedom."

ALEX B. NOVIKOFF

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AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE
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NEW BOOKS OF SCIENTIFIC INTEREST

Atoms, Stars and Nebulae. L. GOLDBERG and L. H. ALLER. Ill. v + 323 pp. $2.50. March, 1943. Blakiston.

This book on astrophysics presents a brief non-mathematical venture into the principles of atomic physics and the theory of light. It then explains the physical processes at work in the interiors and exteriors of stars. Hot, cold, pulsating and exploding stars are discussed.

These Mysterious Rays. A. L. HART. Ill. x + 218 pp. $2.75. May, 1943. Harper.

Dr. Hart, a roentgenologist, gives in this book a nontechnical discussion of the uses—chiefly in medicine—of X-rays, radium and ultraviolet. He also gives a picture of the patients, with their greatly varying problems, who stream through his laboratory from morning until night.

Pioneer to the Past. C. BREASTED. Ill. x + 436 pp. $3.50. April, 1943. Scribner's.

This is a biography of James Henry Breasted, American orientalist and archaeologist, as told by his son. After being a pharmacist, he joined the ministry and then began his oriental studies. Dr. Breasted was the first to teach Egyptology in the United States; he founded the Oriental Institute at the University of Chicago.

Fundamentals of Soil Science. C. MILLAR, L. TURK. Ill. xi + 462 pp. $3.75. 1943. Wiley.

This book was written for use as a college text-book, as a reference book for farmers and owners of farm lands, and as an aid to anyone desiring information on soils and their culture. The general principles of soil science are emphasized.

Trees and Test Tubes. C. M. WILSON. Ill. xii + 352 pp. $3.50. 1943. Holt.

The history of rubber, from its discovery down to the present time of various rubber synthetics, is told in this book. The author includes an account of the current rubber crisis and its future solutions. At the back of the book is the complete text of the Baruch Committee Report.

Memorable Days in Medicine. P. F. and A. S. CLARK. Ill. 305 pp. $2.00. 1942. Wisconsin.

This is a "calendar of biology and medicine." The titles of its twelve chapters are the months of the year, and under the days of the month are accounts of the births, deaths and important work of men outstanding in the history of medicine and biology. Important events are also included and listed separately.

Chimpanzees. A Laboratory Colony. R. M. YERKES. Ill. xv + 321 pp. $5.00. May, 1943. Yale.

This is a composite portrait of chimpanzee personality done in terms of behavior. The author has written the book as much for the layman as for the specialist in the field of psychological research. The book is based primarily on personal experiences of the author, who is professor of psychobiology at Yale University.

The Human Hand. C. WOLFF. Ill. xxiii + 198 pp. $3.00. May, 1943. Knopf.

This volume sets forth a scientific method of analyzing hands. Dr. Wolff, a professional psychologist and physician, tells what the main features of the hand are, in what ways the folding-lines of the palm and the skin-patterns reveal the subject's inner potentialities and sometimes his psychological characteristics.

How to Be Fit. R. KIPHUTH. Ill. xiii + 131 pp. $2.00. 1942. Yale.

This book consists of exercises for men of all ages. It is divided into two parts: general exercises that everyone can do, and more strenuous ones for youngsters. They are designed to work the entire body, including places that ordinary exercise do not touch. The author is director of the gymnasium at Yale University.

The American Leonardo. C. MABEE. Ill. xxix + 420 pp. $5.00. February, 1943. Knopf.

This is a biography of Samuel F. B. Morse. The author wants to show that he should be known not just as a telegrapher and inventor, but also as an artist, promoter, controversialist and man of faith. Much material for the book was obtained through the cooperation of Morse's granddaughter.

The Diffusion of Science. J. L. BENNETT. ix + 141 pp. $2.25. 1942. Johns Hopkins.

This book seeks to envisage the present situation of the "relatively ineffectual" efforts to diffuse science among the general public, and offers a possible plan for the more effective diffusion of science. The author pleads for the application of scientific method to the whole problem of the diffusion of science.

Education Between Two Worlds. A. MEIKLEJOHN. x + 303 pp. $3.00. 1942. Harper.

This book is devoted to an attempt to understand the education which is given by the Anglo-Saxon democracies, to study the learning and teaching which have been done by a Protestant-capitalist civilization, in view of the present war. Included is a comparison of the philosophies of five important educators.

Forward to the Land. E. T. PETERSON. Ill. xvi + 283 pp. $2.75. 1942. Oklahoma.

Mr. Peterson, a former editor of *Better Homes and Gardens*, indicates that there should be a reconstruction, both urban and rural, away from the present tendencies of national socialism and toward "live-at-home-farming." He calls for scientific, balanced, decentralized techniques of farming for effective conservation of resources.

Fun with Your Microscope. R. F. YATES. Ill. ix + 150 pp. $2.00. 1943. Appleton-Century.

This book for the amateur microscopist gives a simplified explanation of the microscope and its use. Besides directions for where and how to find specimens, their mounting and preserving, it includes a discussion of photomicrography and bacteriology.

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RECENT BOOKS OF SCIENTIFIC INTEREST

The Greatest Eye in the World. A. F. COLLINS. Ill. xviii + 266 pp. $3.00. January, 1943. Appleton-Century.

This book is devoted to a history of the astronomical telescope and to a description of the equipment and work being accomplished at eight observatories in the United States, and at the Royal Observatory in England.

Evolution. The Modern Synthesis. J. HUXLEY. 645 pp. $5.00. April, 1943. Harper.

Professor Huxley brings together the latest information on evolutionary progress. He deals with the modern developments of Mendelism and their bearing on evolution, discusses the various methods by which new species may be formed and the general problems of adaptation and geographical variation.

Handbook of Frogs and Toads. 2nd ed. rev. A. A. and A. H. WRIGHT. Ill. xi + 286 pp. $3.00. 1942. Comstock.

This volume supplies a key for the identification of frogs and toads and provides accounts of the appearance, range, habitat, life history, structure, voice, etc., of 98 species and subspecies of frogs and toads of the United States and Canada.

Science in Progress. G. A. BAITSELL, ed. Ill. xiv + 322 pp. $3.00. December, 1942. Yale.

In this book recent developments in the fields of astronomy, physics, biology, medicine and chemistry are discussed by ten well-known men of science. The book is based upon lectures presented in the National Sigma Xi Lectureships; it is the third in the series.

The Methodology of Pierre Duhem. A. LOWINGER. 184 pp. $2.25. November, 1941. Columbia.

This is a study of a Frenchman who has done work in physics and the history of science and whose methodological ideas have influenced logical thought in the United States. The author begins with a nontechnical introduction to the philosophy of science.

Alcohol Addiction and Chronic Alcoholism. E. M. JELLINEK, ed. xxiii + 336 pp. $4.00. October, 1942. Yale.

This treatise is on the etiology of abnormal drinking and its effects on the bodily and mental functions of the individual; the immediate effects of alcohol in any quantity on the organs and their functions and on psychologic behavior.

Civilian Health in Wartime. F. R. DIEUAIDE. vi + 328 pp. $2.50. 1942. Harvard.

Dr. Dieuaide provides the general reader with a statement in broad outline of the varied aspects of health in the United States in relation to the war. The emphasis is placed on the preservation of health. Among the chapters included are: The Nutritional Background: The Aging and the Aged; Mental Calm and Vigor.

Liebig and After Liebig. Edited by FOREST RAY MOULTON. viii + 111 pp. $3.00. 1942. American Association.

A symposium of papers presented before the Sections on Chemistry and Agriculture of the American Association for the Advancement of Science, in commemoration of the hundredth anniversary of the publication of Liebig's "Organic Chemistry in the Applications to Agriculture and Physiology."

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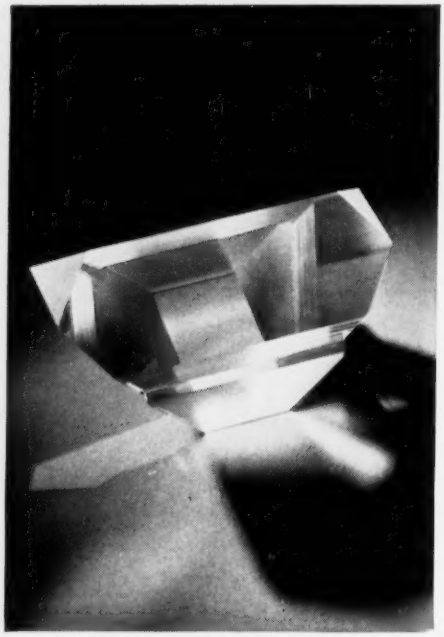

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